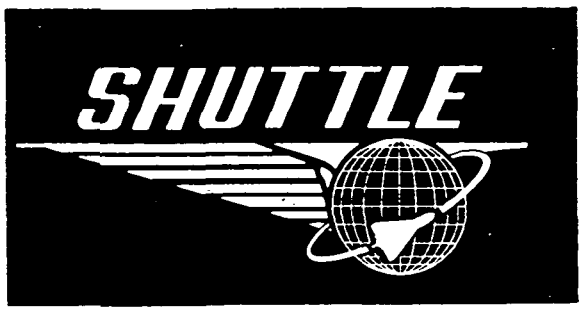

LMSC-A991396
30 JUNE 1973

FINAL REPORT

SHUTTLE CRYOGENICS SUPPLY SYSTEM OPTIMIZATION STUDY

VOLUME V A-2

USERS MANUAL FOR SPACE SHUTTLE ORBIT INJECTION SYSTEM ANALYSIS (SOPSA)

CONTRACT NAS9-11330

Prepared for Manned Spacecraft Center
by
Manned Space Programs, Space Systems Division

LOCKHEED MISSILES & SPACE COMPANY, INC.
A SUBSIDIARY OF LOCKHEED AIRCRAFT CORPORATION

DRL Line Item 9
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FOREWORD

This Final Report provides the results obtained in the Shuttle Cryogenics Supply System Optimization Study, NAS 9-11330, performed by Lockheed Missiles & Space Company (LMSC) under contract to the National Aeronautics and Space Administration, Manned Spacecraft Center, Houston, Texas. The study was under the technical direction of Mr. T. L. Davies, Cryogenics Section of the Power Generation Branch, Propulsion and Power Division. Technical effort producing these results was performed in the period from October 1970 to June 1973.

The Final Report is published in eleven volumes*:

Volume I	– Executive Summary
Volumes II, III, and IV	– Technical Report
Volume VA-1 and VA-2 Math Model	– Users Manual
Volume VB-1, VB-2, VB-3, and VB-4 Math Model	– Programmers Manual
Volume VI	– Appendixes

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*The Table of Contents for all volumes appears in Volume I only. Section 12 in Volume III contains the List of References for Volumes I through IV.

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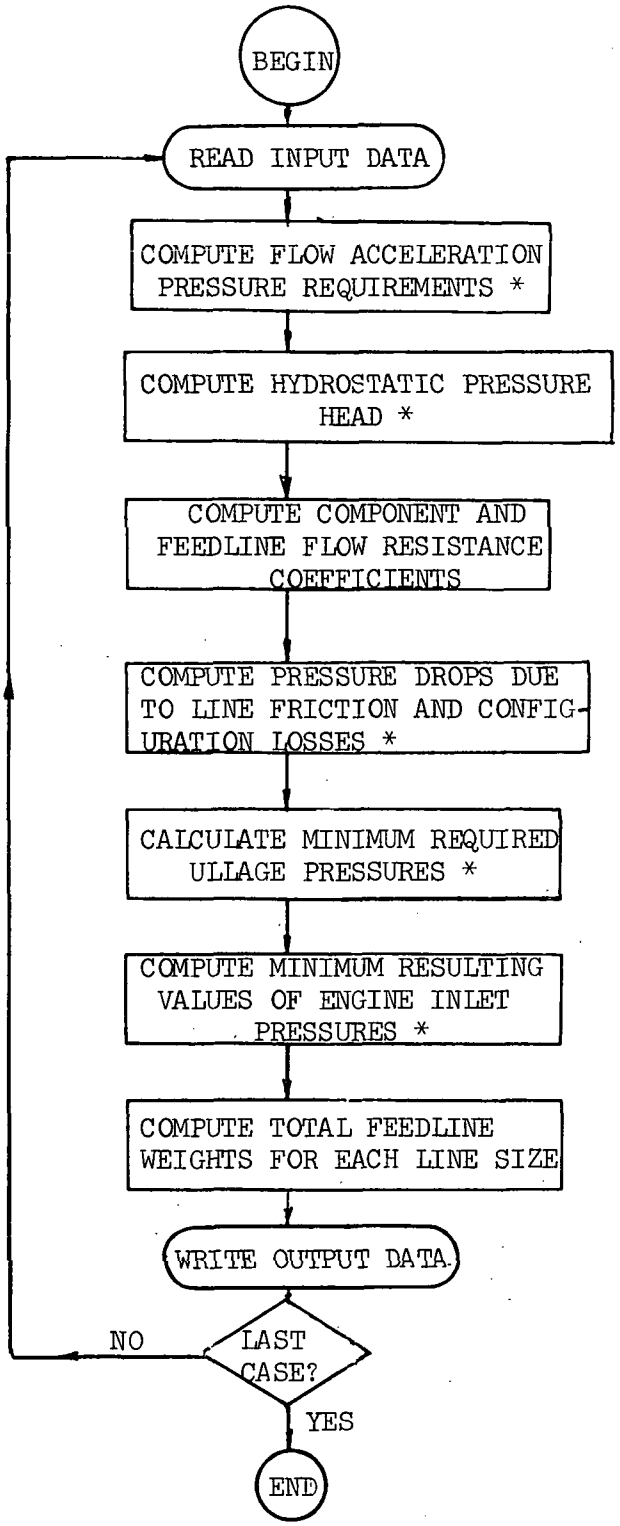
INTRODUCTION

SOPSA (Shuttle Orbit Injection Propulsion System Analysis) is a computer program developed by Lockheed Missiles & Space Company to aid in the preliminary design of propellant feed systems for the Space Shuttle Orbiter main engines. The primary purpose of the program is to evaluate propellant tank ullage pressure requirements imposed by the need to accelerate propellants rapidly during the engine start sequence. These requirements can influence the system design for a given engine as well as the suitability of a given system for use with different engines. During the vehicle design phase, the SOPSA program is used to establish feed system weight variations as a function of nominal line diameter and component and line configurations. The weight data are used in conjunction with pertinent cost data to establish optimum feed system designs.

The SOPSA program will generate parametric feed system pressure histories and weight data for a range of nominal feedline sizes. This is accomplished by evaluating tank ullage pressure requirements during the startup phase using the constraints of engine inlet pressure (or NPSP) requirements and instantaneous values of feedline flow resistance. Program flexibility has been incorporated to allow for engine start on the ground or at altitude, computations for oxidizer, fuel, or both oxidizer and fuel feedlines, and a multiple restart capability requiring restart data input only for quantities whose values have changed from the previous case.

As illustrated in the main program flow diagram, Figure 1, the SOPSA program utilizes a simple, in-line computational sequence to solve for the propellant tank ullage pressure requirements. Input data describe the number of main propellant feedline sizes to be considered, and the number of engine feedlines attached to each main feedline (i.e., the number of branch lines feeding each



* NOTE: THESE CALCULATIONS ARE PERFORMED AS A FUNCTION OF TIME FOR EACH CANDIDATE LINE SIZE.

Fig. 1 SOPSA Main Program Flow Diagram

engine). The number and type of components in each line are described, with up to 23 line components currently being available. These components include straight and curved line sections, valves, bellows, venturi's and PVC's. (The program computes component weights and flow resistance coefficients and display total values for each line as part of the output data.) Engine flowrate, NPSP and thrust profiles during the startup transient are also input. In addition propellant tank geometry and propellant and vehicle weights are required, along with input data control flags and miscellaneous boundary conditions.

As illustrated in Fig. 1, the program will compute the various pressure drop components needed to evaluate tank pressure requirements during engine start. These calculations are performed for each candidate main feedline size (engine feedlines sizes assumed fixed) as a function of time throughout the start transient. Feedline weights are computed based on the maximum value of engine inlet pressure, the maximum value of tank bottom pressure, or an input design pressure, whichever is greatest.

The output data display consists of reformatted input data, feedline flow resistance coefficients, time-varying values of the pressure drop components due to hydrostatic head, flow acceleration, and line friction and configuration losses. Computed values of nominal and minimum required values of tank ullage pressure are displayed, as well as tank bottom and engine inlet pressures. Total feedline system weights are also output for each candidate main feedline size.

In summary, the present SOPSA capabilities are as follows:

- Performs pressure drop calculations for up to four engines per main feedline
- Handles up to 12 candidate main feedline sizes per engine

- Computes component weight and flow resistance for up to 100 components in each feedline

- Input options available to describe 23 types of components, 7 material types, and 6 insulation types

- Operates on the UNIVAC 1108 computer utilizing the EXEC 8 operating system

- Approximate computer run time is 6 seconds per case

Section 1

SOPSA PROPELLANT FEED SYSTEM ANALYSIS PROGRAM

A major consideration in the design of propellant tanks and feed systems for the Space Shuttle Orbiter vehicle is the requirement that propellants be accelerated rapidly during the engine start sequence. Propellant tank structural design is influenced by the maximum ullage pressure levels required to provide sufficient flow acceleration, as well as hydrostatic pressure levels incurred during boost. Flow acceleration requirements, in turn, are dictated by pressure levels required to provide specified propellant flowrates at the engine during startup, while simultaneously satisfying minimum NPSP and inlet pressure requirements. Propellant feed system weights and flow resistance are influenced by component size and design pressure levels. Thus optimization of feed system design requires values of tank ullage pressure as a function of feedline diameter as well as feed system weight. The SOPSA program is designed to compute required pressure values and feed system weights for a range of main feedline diameters.

1.1 PROGRAM DESCRIPTION

Required values of propellant tank ullage pressures during engine start are determined by the pressures required to accelerate the propellant at the rate necessary to supply required flowrates at the engine. A proper accounting of the system pressure drops yields the following relation for ullage pressure requirement at any time during the start transient:

$$P_u(t) = P_{min} - \underset{\text{Head}}{\Delta P(t)} + \Delta P_F(t) + \Delta P_{ACC}(t) + P_{TOL} \qquad (1)$$

where P_{min} = Maximum value of $\left\{ \begin{matrix} P_{NPSP} + P_{VAP} \\ \text{or} \\ P_{ENG} \end{matrix} \right\}$

P_{NPSP} = Engine NPSP requirement

P_{VAP} = Propellant vapor pressure at engine inlet

P_{ENG} = Minimum engine inlet pressure

ΔP_{HEAD} = Hydrostatic pressure at engine inlet due to vehicle acceleration

ΔP_{F} = Pressure drop due to friction in main feedline and engine feedlines

ΔP_{ACC} = Pressure drop required to accelerate propellant to meet the specified flowrate variation during startup

P_{TOL} = Component pressure control tolerance

The pressure control tolerance is generally interpreted to be a combined tolerance on ullage pressure controls and engine inlet requirements.

Equation (1) is solved for an assumed feedline configuration employing a single main feedline for each propellant with up to four branching engine feedlines. This arrangement is illustrated schematically in Fig. 2. Feed systems employing dual main feedlines can be analyzed by restarts or separate runs. Currently, the program is restricted to consider liquid oxygen as the oxidizer and liquid hydrogen as the fuel. An input data flag (SYSNUM) is used to specify whether computations are to be performed for the oxidizer system, fuel system or both feed systems. A ground start flag (NGST) is used to distinguish between engine start on the ground (g/g_o = 1.0) or at altitude (g/g_o = Total Thrust/Vehicle Mass) for purposes of hydrostatic head computations.

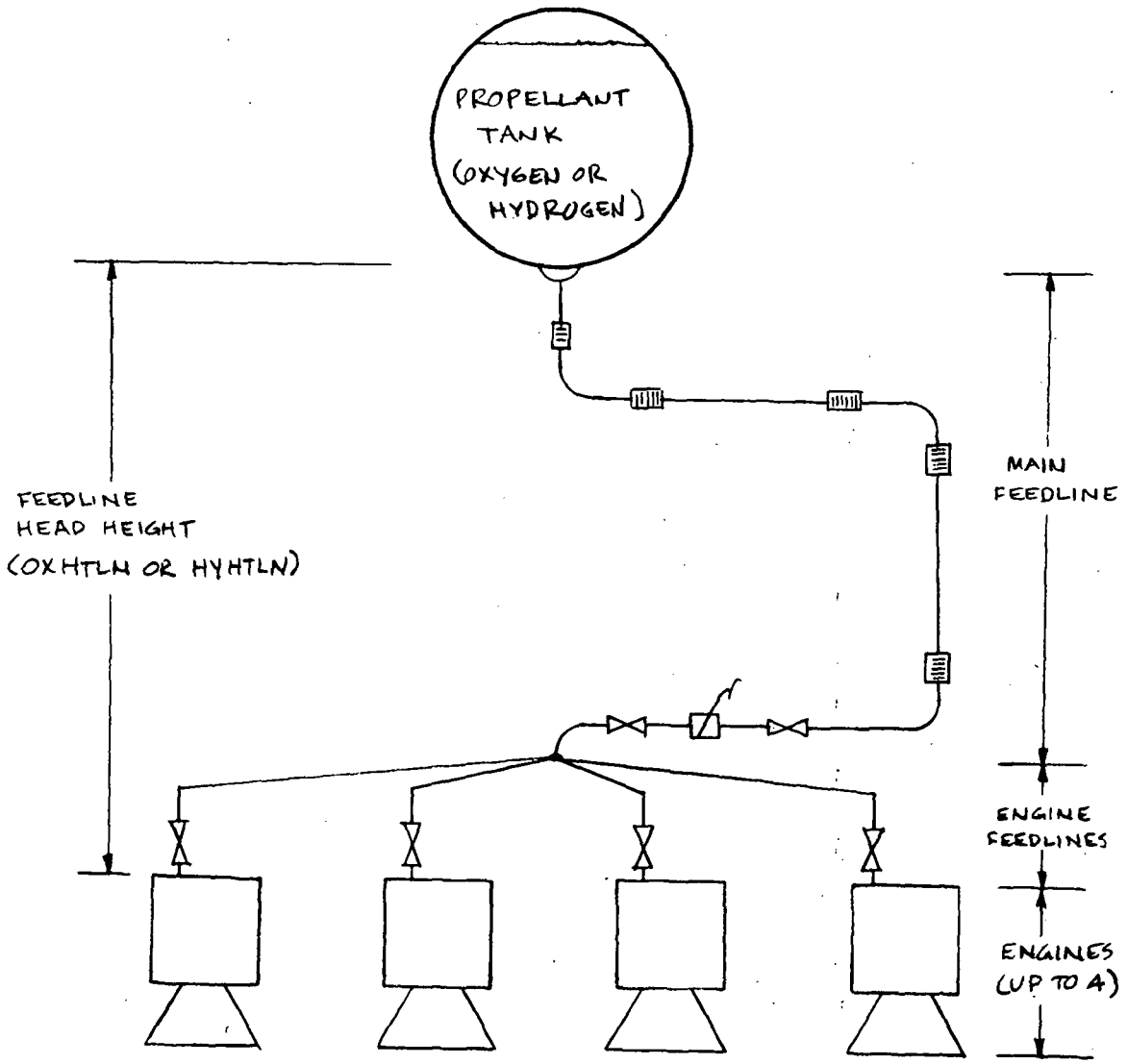


Fig. 2 Propellant Feed System Schematic

1.1.1 Feedline Configuration Description

It is assumed that a single main feedline (for a given propellant) supplies fluid up to four engine feedlines. The number of engine feedlines is denoted by the integer NEL (NEL = 1, 2, 3 or 4). The feedline components are numbered sequentially beginning at the propellant tank outlet; the type of component in the sequence is denoted by an identification number. The maximum number of components in each main feedline is 100. The maximum number of components in each engine feedline is also 100.

In addition to the identification number, each component may also require specification of material type as well as additional configuration data. Thus the component specification input data fields will generally include the following data:

- Identification Number
- Material Type Flag
- Insulation Type Flag
- Configuration Specification (1)
- Configuration Specification (2)

The types of components currently available, their identification numbers, and auxiliary specification requirements are listed in Table 1-1. The material and insulation flags are defined in Tables 1-2 and 1-3. Input data descriptions for components 3-8 are provided in Figs. 3 through 8.

1.1.2 Propellant Tank Configuration Description

Propellant tank geometry is described by nine linear dimensions, as shown in Fig. 9. It is assumed that the oxidizer tank is forward of the fuel tank, and that the tanks are cylindrical with spheroidal or ellipsoidal domes. It is also assumed that a single, common bulkhead separates the oxidizer tank from the fuel tank.

Table 1-1

FEEDLINE COMPONENT SPECIFICATIONS

COMPONENT TYPE	IDENTIFICATION NUMBER (TYPE FLAG)	M MATERIAL FLAG REQUIRED	INSULATION FLAG REQUIRED	SPECIFICATION[5] NO. 1	SPECIFICATION[5] NO. 2	SPECIFICATION[8] NO. 3
SUMP[6]	1	NO	NO	NA	NA	NA
STRAIGHT LINE SECTION	2	YES	YES	LENGTH	NA	INSULATION THICKNESS
CURVED LINE SECTION (BEND)	3	YES	YES	LENGTH	BEND RADIUS	INSULATION THICKNESS
COMPOUND "U" ELBOW[1]	4	YES	YES	LENGTH	BEND RADIUS	INSULATION THICKNESS
NINETY-DEGREE OFFSET BEND[1]	5	YES	YES	LENGTH	BEND RADIUS	INSULATION THICKNESS
"Z" BEND[1]	6	YES	YES	LENGTH	BEND RADIUS	INSULATION THICKNESS
GRADUAL EXPANSION	7	YES	YES	LENGTH	INLET/EXIT DIAMETER RATIO	INSULATION THICKNESS
CONTRACTION	8	YES	YES	LENGTH	INLET/EXIT DIAMETER RATIO	INSULATION THICKNESS
SINGLE LEG OF DIVERGING BRANCH[7]	9	-	-	-	-	-
VENTURI	10	YES	NO	LENGTH	THROAT DIAMETER/ INLET DIAMETER	INSULATION THICKNESS
FLOWMETER[7]	11	-	-	-	-	-
GATE VALVE[7]	12	-	-	-	-	-
BUTTERFLY VALVE, MEDIUM WEIGHT[2]	131	NO	NO	NA	NA	NA
BUTTERLY VALVE, HEAVY WEIGHT[3]	132	NO	NO	NA	NA	NA
BUTTERLY VALVE, EXTRA HEAVY WEIGHT[4]	133	NO	NO	NA	NA	NA
POPPET VALVE, MEDIUM WEIGHT[2]	141	NO	NO	NA	NA	NA
POPPET VALVE, HEAVY WEIGHT[3]	142	NO	NO	NA	NA	NA
POPPET VALVE, EXTRA HEAVY WEIGHT[4]	143	NO	NO	NA	NA	NA
BALL VISOR VALVE	15	NO	NO	NA	NA	NA
DISCONNECT	16	NO	NO	NA	NA	NA
U-PIN TIE ROD BELLOWS	17	NO	NO	NA	NA	NA
PIN OR HINGE JOINT BELLOWS	18	NO	NO	NA	NA	NA
EXTERNAL GIMBAL BELLOWS (W/O LINER)	19	NO	NO	NA	NA	NA
EXTERNAL GIMBAL BELLOWS (WITH LINER)	20	NO	NO	NA	NA	NA
INTERNAL GIMBAL BELLOWS (W/O LINER)	21	NO	NO	NA	NA	NA
PRESSURE-VOLUME COMPENSATOR	22	NO	NO	NA	NA	NA
INTERNAL BALL-STRUT BELLOWS	23	NO	NO	NA	NA	NA

NOTES:
(1) CONFIGURATIONS DEFINED IN FIG. 3
(2) MODULATION, SHUTOFF, FILL, ISOLATION VALVES
(3) PRESSURE REGULATORS, FLOW CONTROLS AND MIX VALVES
(4) SOLENOID AND BALL VALVES
(5) ALL DIMENSIONS IN FEET, LENGTHS ARE TOTAL CURVILINEAR CENTERLINE LENGTHS
(6) SUMP WEIGHT IS NOT COMPUTED
(7) THIS OPTION NOT CURRENTLY IMPLEMENTED
(8) INSULATION THICKNESS INPUT IN INCHES

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Table 1-2

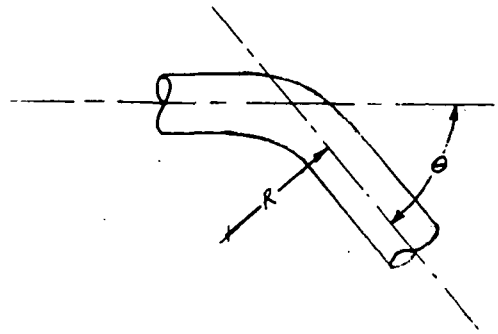
COMPONENT MATERIAL FLAGS

MATERIAL FIAG	MATERIAL TYPE
1	321/347 Stainless Steel
2	2219-T87 Aluminum Alloy
3	6061-T6 Aluminum Alloy
4	Inconel-718 Alloy
5	Titanium TI-6AL-4V Alloy
6	CRES Vacuum Jacketed Line
7	2219 Vacuum Jacketed Line

Table 1-3

INSULATION MATERIAL FLAGS

INSULATION FIAG	INSULATION TYPE
1	Double Alum. Mylar/Silk Net (50-60 L/In)
2	Double Gold Mylar/Silk Net (50-60 L/In)
3	NRC-2 Crink. Al. Mylar (40 L/In)
4	Superfloc (30 L/In)
5	Polyurethane Foam
6	Fiberglass Batting

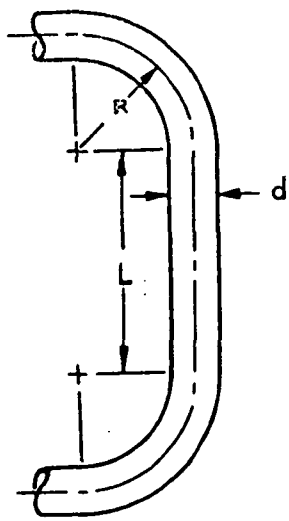


$0 < \theta \leq 180°$

SPEC1 = LENGTH = $R \times \left(\frac{\theta}{57.3}\right)$, θ IN DEGREES, R IN FEET

SPEC2 = BEND RADIUS = R, FEET

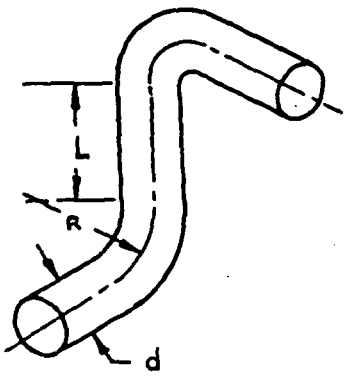
Fig. 3 Inputs For Curved Line Section



SPEC 1 = LENGTH = $L + \pi R$; L, R IN FEET

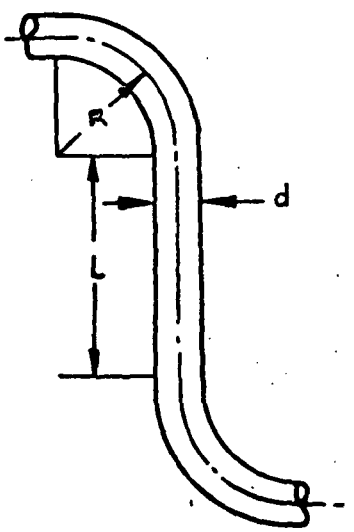
SPEC 2 = BEND RADIUS = R; FEET

Fig. 4 Inputs For Compound "U" Elbow



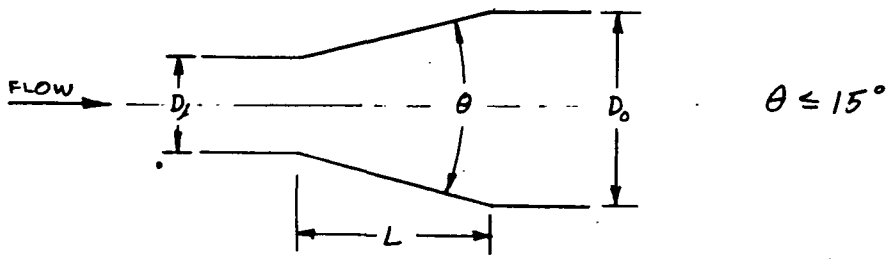
SPEC1 = LENGTH = L + πR ; L, R IN FEET
SPEC2 = BEND RADIUS = R, FEET

Fig. 5 Inputs for 90° Offset Bend



SPEC1 = LENGTH = L + πR ; L, R IN FEET
SPEC2 = BEND RADIUS = R, FEET

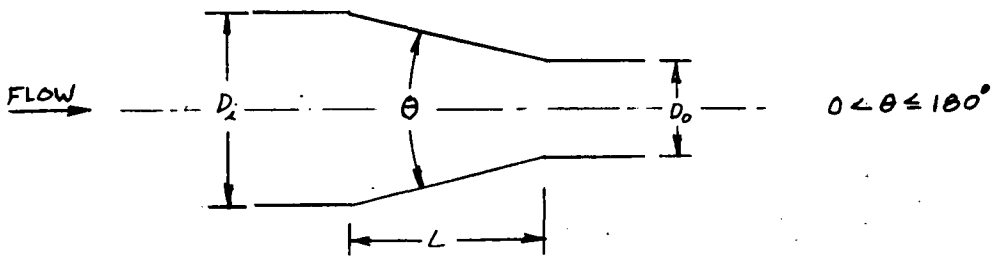
Fig. 6 Inputs for "Z" Bend



SPEC1 = LENGTH = L, FEET

SPEC2 = D_i/D_o

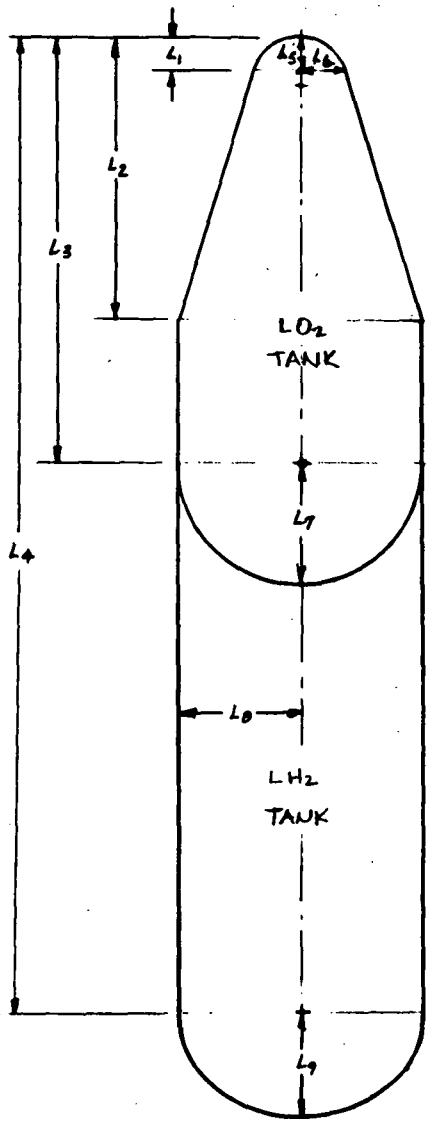
Fig. 7 Inputs For Gradual Expansion



SPEC1 = LENGTH = L, FEET

SPEC2 = D_i / D_o

Fig. 8 Inputs For Contraction



- HEMISPHERICAL, SPHEROIDAL OR ELLIPSOIDAL DOMES
- LO_2 TANK FORWARD OF LH_2 TANK
- COMMON BULKHEAD BETWEEN LO_2 AND LH_2 TANKS

GEOMETRY INPUT VIA VARIABLE EQLR(I), I=1,9.

EQLR(1) = L_1
EQLR(2) = L_2
⋮ ⋮
EQLR(9) = L_9

Fig. 9 Propellant Tank Configuration Definition

1.2 INPUT DATA

The input deck structure is designed so that several cases may be processed during one run. Also, only the data groups which vary from one case to the next need be input. The input data consist of two header cards followed by 16 input groups (I.G.'s). The data input sequence is as follows:

- Case Title Card (First Header Card)
- Input Data Flags (Second Header Card)
- Feed System Configuration Descriptions (I.G.'s 1-5)
- Fixed Input Data (I.G.'s 6, 7 and 8)
- Time-Varying Imput Data (I.G.'s 9-15)
- Restart Card (I.G. 16)

The overall organization of the input data deck is illustrated in Fig. 10.

The case title card contains an alphanumeric description whose contents are determined by the user. The input data flag card contains a series of 16 integer digits corresponding to the 16 input data groups. A one (1) in the position corresponding to a given input group indicates that data cards for that group are present in the data deck. A zero (0) indicates that data for that group are not present, so that data from a previous case are to be used in computations for the current case. Thus all the input data flags must equal to one (1) for the first case. (Note that for the final case in a run the value of the data flag for I.G. 16 must be equal to one (1) so that the program will read the restart card.) Both header cards (the title card and the data flag card) must be input for each case.

The input data describing the propellant feed system configuration include the number of main and engine feedline sizes to be considered, the number of engines on the vehicle, the number of time points for which transient start data will be input and the ground start flag. These are followed by data describing the tank and feedline configurations, as discussed in sections 1.1.1 and 1.1.2 above.

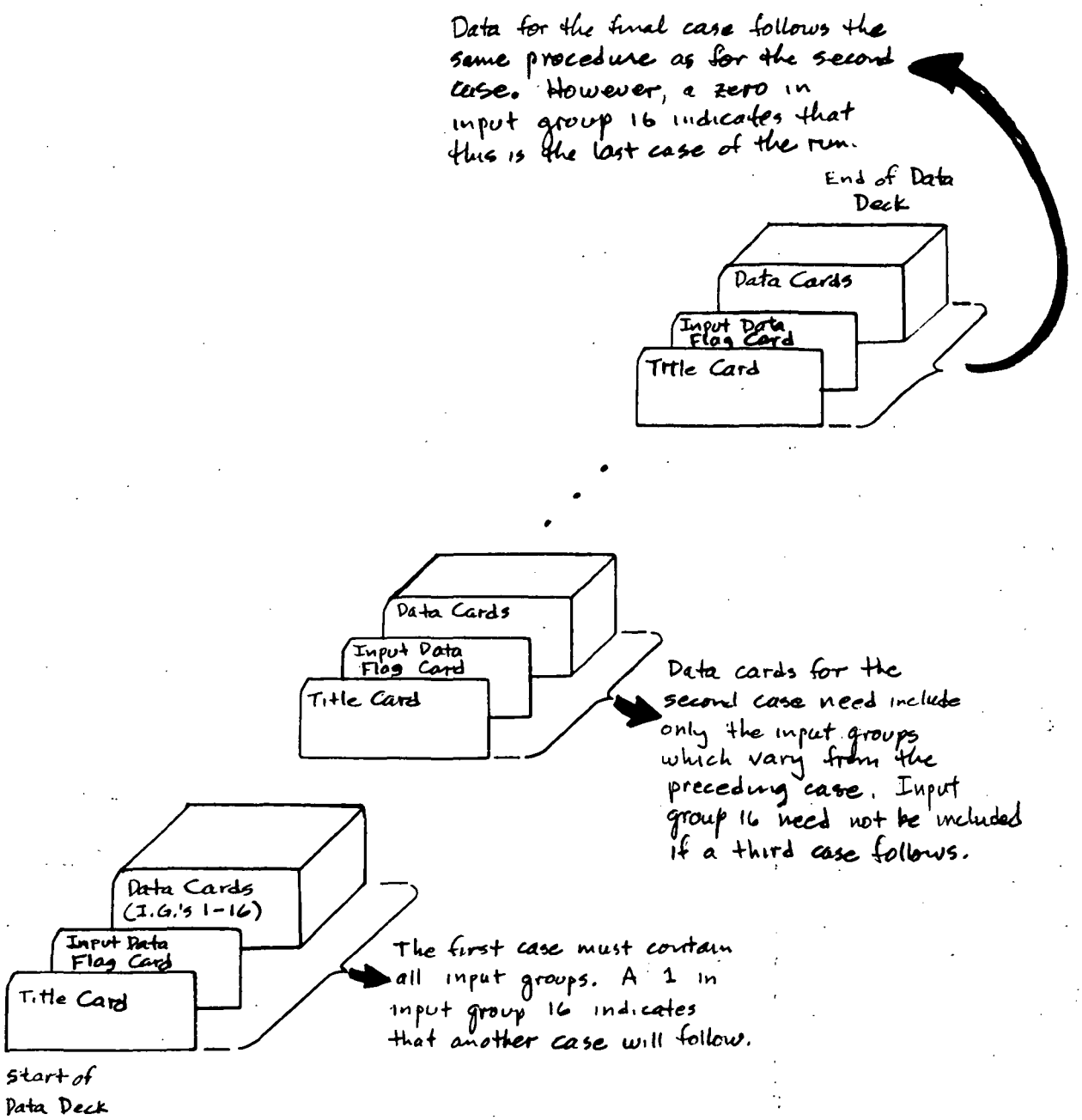


Fig. 10 Input Data Deck Organization

Fixed input data include values of loaded propellant masses, nominal (steady-state) values of propellant flowrates and engine thrust, propellant temperatures at the engine inlet and the liquid surface in the tank, and the engine inlet pressure tolerance.

Time-varying inputs are used to describe the variation of engine flowrate, thrust and NPSP requirements during the start transient. Additional inputs which are also time-dependent include data describing minimum engine inlet pressure requirements, partial-pressures of propellant tank pressurant gas, and pressurant gas inlet temperatures.

The definitions of input data quantities and input data formats are provided on the format sheets shown in Appendix A. The format for the title card is FORTRAN 7A6; the format for the input data flag card is FORTRAN 16I1; the format for the feedline configuration data is FORTRAN (3I6, 3E12.8). The formats for the remaining input data are either FORTRAN ((6E12.8)) for floating point data or FORTRAN ((12I6)) for integer data.

1.3 INPUT DECK SETUP

The input deck consists of a set of control cards, a set of input data, and an end-of-run (FIN) card. The set of input data cards is arranged as shown in Fig. 10. Thus, the deck setup for a complete run is as shown on Fig. 11. Use of the deck configuration shown in this figure assumes that the program deck has already been compiled and placed on a mass storage file under the name SØPSA. The control cards illustrated apply to usage on the UNIVAC 1108 computer operating under the EXEC 8 control system.

1.4 CONTROL CARDS

Control cards required to operate the SOPSA program consist of those cards necessary to assign and execute program storage files under the appropriate control system. The control statements required for operation on the UNIVAC

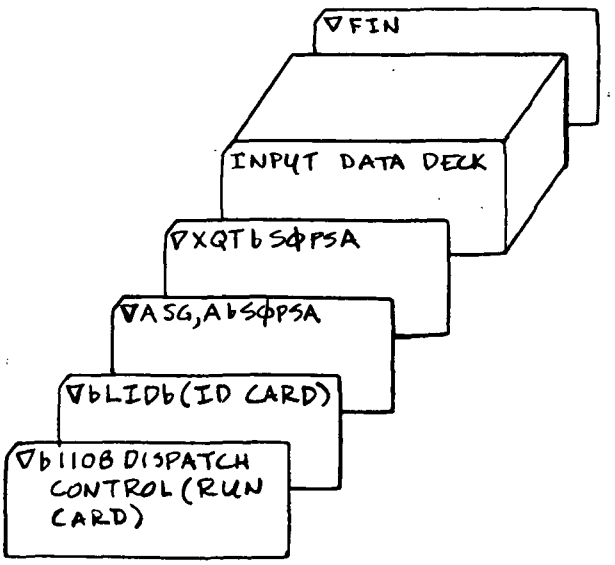


Fig. 11 Input Deck Setup

1108, EXEC 8 system have been described in Section 1.3.

1.5 OUTPUT DATA

Sample output data for SØPSA are shown in Table 2-4. An accompanying description of output quantities is provided in Section 2.2.

1.6 ERROR MESSAGES

No diagnostic error messages are currently provided in the SØPSA program.

1.7 RESTRICTIONS

Input data restrictions occur as a result of dimension limits on program variables and output data formatting limits. These limits apply primarily to descriptions of the feedline configuration and the propellant tank configuration, as described in Sections 1.1.1 and 1.1.2.

In addition, the number of time points used to describe transient input data is restricted to a maximum of 21 (cf. input groups 9-15, Appendix A).

Section 2
SOPSA DATA SAMPLES

In order to illustrate the application of the SOPSA program, a sample problem has been set up utilizing a feed system configuration typical of those designed for the external fuel tanks for the Space Shuttle orbit injection propulsion system. The feed system configurations are shown in Figs. 12 and 13. Corresponding lists of feedline components are given in Tables 2-1 and 2-2. Values of input data parameters required to describe these components are also listed. These parameters are obtained from the component characteristics listed in Table 1-1.

2.1 INPUT DATA LISTING

A listing of an input data deck for the feed system described above is shown in Table 2-3. For purposes of illustration each card has been labeled in columns 73-80. Definitions of individual input quantities can be obtained by referring to the input data formats given in Appendix A. It may be seen from Table 2-3 that a restart case has been added at the end of the first case (IGØØN = 1 at end of first case). In the data for the second case only a single input group has been changed (I.G. 13) so that only new values of data for this group are provided (i.e., revised values of PENMNØ and PENMNH).

2.2 OUTPUT DATA LISTING

Output for the first case of the sample problem is listed in Table 2-4.

A listing of several of the fixed input data quantities is shown on the first page, along with computed values of tank surface areas and liquid head heights. Tank and feedline configuration input data are listed on the next three pages. The feedline data listing also includes computed values of line lengths and

flow resistance coefficients (K-factors). On the next page are listed values of time-varying input data quantities as defined in the input data formats.

Computed values of various significant transient feed system parameters are presented on the next page. These include the time derivative of propellant flowrates (WDDØT), total vehicle weight, thrust-to-weight ratio (always equal to one for a ground start), hydrostatic pressure head at the engine inlet (DELPHD), incremental propellant usage (PRØP-Ø-INCR and PRØP-F INCR), cumulative propellant used (PRØP-TØT CUM) and minimum inlet pressure requirements at the engine inlet (PENG ØXID and PENG FUEL). The latter quantities may differ from input values of PENMNØ and PENMNH if the sum of propellant vapor pressure plus engine NPSP is higher than these input quantities.

The next two blocks of output contain computed values of the increment in pressure required to accelerate the propellant to meet specified flowrate requirements (ΔP_{ACC}) for the main feedlines. This is followed by two similar output blocks displaying computed values of main feedline pressure drops due to line friction and configuration losses. The next two pages of output contain similar data for the engine feedlines.

This is followed by a printout of the nominal propellant tank ullage pressures required in the two feed systems. These pressure values reflect only the requirement implied by the solution of Equation (1), Section 1.1. Thus the nominal requirements may be less than the ullage pressure required to suppress propellant boiling, as shown in the output for the oxidizer tank.

The next output block contains a listing of several intermediate quantities. These include, in order,

- Propellant vapor pressure at the liquid surface (ULLVAP)
- Minimum ullage pressure required for main feedline No. 1 (MINULL)
- Tank bottom pressure for feedline No. 1 (TNKBØT)
- Line head pressure components (LINHED)
- Tank Ullage Volumes (ULLVØL)

- Tank head heights (TNKHED)
- Ullage vapor weights

The nominal ullage pressure requirements are checked against the vapor pressure requirements in the propellant tank and revised, if necessary, to produce minimum required values of ullage pressure. These values are printed in the next two output blocks for oxygen and hydrogen feed systems, respectively.

Revised tank bottom pressures (based on minimum required ullage pressures) are output in the succeeding two output blocks.

The recomputed values of engine inlet pressures (using final minimum ullage pressure values) are then printed out.

The final output block contains a summary of total feedline and insulation weights for each of the candidate main feedline sizes. It should be noted that zero-values for insulation weights are shown for the hydrogen system, since a vacuum-jacketed feed system was specified.

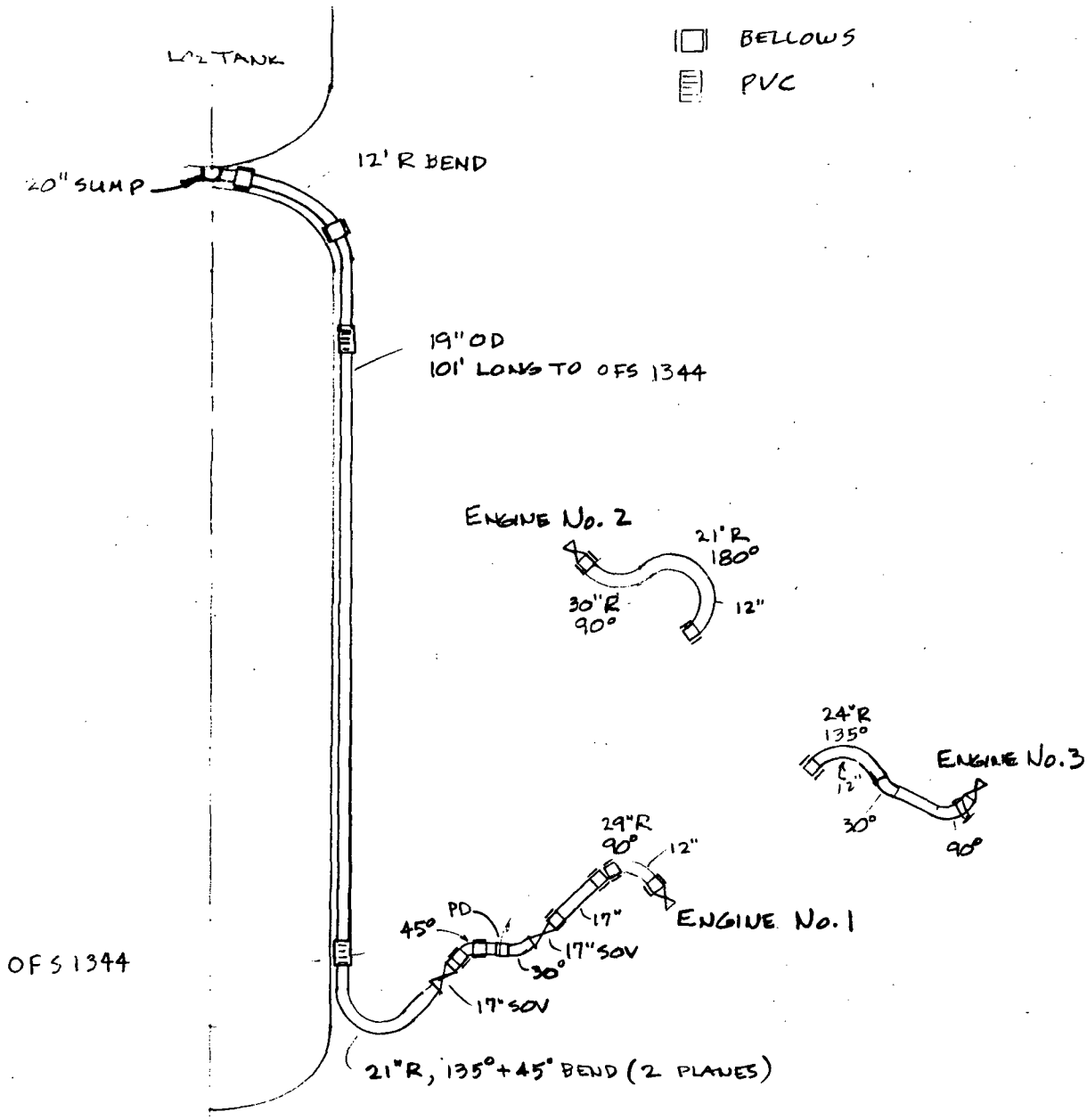


Fig. 12 Oxygen Feed System - Orbiter 040A

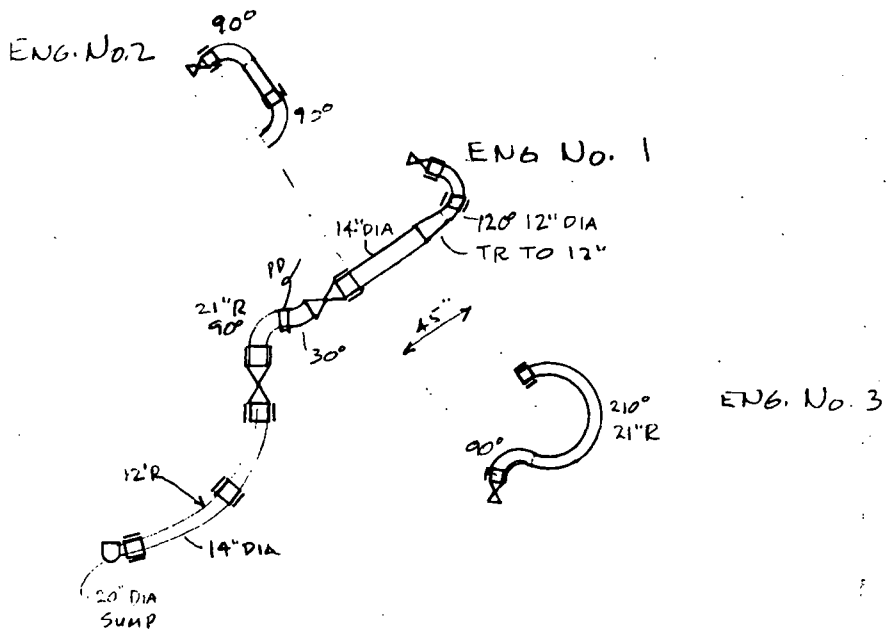


Fig. 13 Hydrogen Feed System - Orbiter 040A

Table 2-1

HYDROGEN FEED SYSTEM CONFIGURATION

SECTION	COMPONENT	ID	IM	II	SPEC1	SPEC2	SPEC3
Main Feed Line	Sump	1	-	-	-	-	-
	Straight Line	2	7	-	1.0	-	-
	Bellows	20	-	-	-	-	-
	Bend	3	7	-	9.44	12.0	-
	Bellows	20	-	-	-	-	-
	Bend	3	7	-	9.44	12.0	-
	Bellows	20	-	-	-	-	-
	Ball Visor Valve	15	-	-	-	-	-
	Bend	3	7	-	2.75	1.75	-
	Disconnect	16	-	-	-	-	-
	Bend	3	7	-	0.92	1.75	-
	Ball Visor Valve	15	-	-	-	-	-
	Bellows	20	-	-	-	-	-
Main Feed Line	Straight Line	2	7	-	3.75	-	-
Eng. Line No. 1	Transition	8	7	-	1.0	1.35	-
	Bellows	20	-	-	-	-	-
	Bend	3	7	-	3.14	1.5	-
	Bellows	20	-	-	-	-	-
Eng. Line No. 1	Ball Visor Valve	15	-	-	-	-	-
Eng. Line No. 2	Bend	3	7	-	2.35	1.5	-
	Compound Elbow	4	7	-	7.5	1.5	-
	Bellows	20	-	-	-	-	-
Eng. Line No. 2	Ball Visor Valve	15	-	-	-	-	-
Eng. Line No. 3	Bellows	20	-	-	-	-	-
	Bend	3	7	-	2.35	1.5	-
	Bend	3	7	-	9.15	1.75	-
	Bend	3	7	-	5.49	1.75	-
	Bellows	20	-	-	-	-	-
Eng. Line No. 3	Ball Visor Valve	15	-	-	-	-	-

Table 2-2

OXYGEN FEED SYSTEM CONFIGURATION

SECTION	COMPONENT	ID	IM	II	SPEC1	SPEC2	SPEC3
Main Feed Line	Sump	1	-	-	-	-	-
	Bend	3	2	5	5.0	20.0	0.75
	Bellows	20	-	-	-	-	-
	Bend	3	2	5	9.16	13.33	0.75
	Bellows	20	-	-	-	-	-
	Bend	3	2	5	4.16	8.33	0.75
	Straight Line	2	2	5	7.0	-	0.75
	PVC	22	-	-	-	-	-
	Straight Line	2	2	5	72.0	-	0.75
	PVC	22	-	-	-	-	-
	Straight Line	2	2	5	4.0	-	0.75
	Bend	3	2	5	4.1	1.75	0.75
	Bend	3	2	5	1.38	1.75	0.75
	Straight Line	2	2	5	4.0	-	0.75
	Ball Visor Valve	15	-	-	-	-	-
	Bellows	20	-	-	-	-	-
	Bend	3	2	5	1.0	1.27	0.75
	Bellows	20	-	-	-	-	-
	Straight Line	2	2	5	1.5	-	0.75
	Disconnect	16	-	-	-	-	-
	Bend	3	2	5	4.0	7.65	0.75
	Ball Visor Valve	15	-	-	-	-	-
	Bellows	20	-	-	-	-	-
	Straight Line	2	2	5	7.0	-	0.75
	Bellows	20	-	-	-	-	-
Main Feed Line	Transition	8	2	5	1.0	1.5	0.75
Eng. Line No. 1	Bellows	20	-	-	-	-	-
	Bend	3	2	5	3.8	1.5	0.75

Table 2-2 (Cont.)

OXYGEN FEED SYSTEM CONFIGURATION

SECTION	COMPONENT	ID	IM	II	SPEC1	SPEC2	SPEC3
Eng. Line No. 1	Bellows	20	-	-	-	-	-
	Ball Visor Valve	15	-	-	-	-	-
Eng. Line No. 2	Bellows	20	-	-	-	-	-
	Bend	3	2	5	5.5	1.75	0.75
	Bend	3	2	5	3.93	2.5	0.75
	Bellows	20	-	-	-	-	-
	Ball Visor Valve	15	-	-	-	-	-
Eng. Line No. 3	Bellows	20	-	-	-	-	-
	Bend	3	2	5	4.71	2.0	0.75
	Bend	3	2	5	1.5	2.86	0.75
	Bellows	20	-	-	-	-	-
Eng. Line No. 3	Ball Visor Valve	15	-	-	-	-	-

Table 2-3

SOPSA INPUT DATA LISTING

```
 SAMPLE CASE - ORBITER 040A. LOW PENMN                                    TITLE
 1111111111111111                                                         DATAFLGS
      3    12     3     3     3    21     2                              NML,ETC.
 143.          39.                                                        TOTML
 120.          549.          551.          1691.         120.          120.  EQLR1
 129.          181.          129.                                         EQLR1
      26     4     5     7                                               MIDLO
       1                                                                  IDMLO
       3     2     55.           20.           .75                       IDMLO
      20                                                                  IDMLO
       3     2     59.16         13.33         .75                       IDMLO
      20                                                                  IDMLO
       3     2     54.16         8.33          .75                       IDMLO
       2     2     57.                         .75                       IDMLO
      22                                                                  IDMLO
       2     2     572.                        .75                       IDMLO
      22                                                                  IDMLO
       2     2     54.                         .75                       IDMLO
       3     2     54.1          1.75          .75                       IDMLO
       3     2     51.38         1.75          .75                       IDMLO
       2     2     54.                         .75                       IDMLO
      15                                                                  IDMLO
      20                                                                  IDMLO
       3     2     51.           1.27          .75                       IDMLO
      20                                                                  IDMLO
       2     2     51.5                        .75                       IDMLO
      16                                                                  IDMLO
       3     2     54.           7.65          .75                       IDMLO
      15                                                                  IDMLO
      20                                                                  IDMLO
       2     2     57.                         .75                       IDMLO
      20                                                                  IDMLO
       6     2     51.           1.5           .75                       IDMLO
      20                                                                  IDEL01
       3     2     53.8          1.5           .75                       IDEL01
      20                                                                  IDEL01
      15                                                                  IDEL01
      20                                                                  IDEL02
       3     2     55.5          1.75          .75                       IDEL02
       3     2     53.93         2.5           .75                       IDEL02
      20                                                                  IDEL02
      15                                                                  IDEL02
      20                                                                  IDEL03
       3     2     54.71         2.            .75                       IDEL03
       3     2     51.5          2.86          .75                       IDEL03
       2     2     53.                         .75                       IDEL03
       3     2     53.8          1.5           .75                       IDEL03
      20                                                                  IDEL03
      15                                                                  IDEL03
 12.           12.           12.           12.           13.           14.  OPD
 15.           16.           17.           18.           19.           20.  OPD
 21.           22.           23.                                          OPD
      14     5     4     6                                               MIDLH
       1                                                                  IDMLH
       2     7     1.                                                    IDMLH
      20                                                                  IDMLH
       3     7     9.44          12.                                     IDMLH
      20                                                                  IDMLH
       3     7     9.44          12.                                     IDMLH
      20                                                                  IDMLH
      15                                                                  IDMLH
```

Table 2-3

SOPSA INPUT DATA LISTING (CONT'D)

```
      3      7      2.75         1.75                                    IDMLH
     16                                                                  IDMLH
      3      7      .92          1.75                                    IDMLH
     15                                                                  IDMLH
     20                                                                  IDMLH
      2      7      3.75                                                 IDMLH
      8      7      1.           1.35                                    IDELH1
     20                                                                  IDELH1
      3      7      3.14         1.5                                     IDELH1
     20                                                                  IDELH1
     15                                                                  IDELH1
      3      7      2.35         1.5                                     IDELH2
      4      7      7.5          1.5                                     IDELH2
     20                                                                  IDELH2
     15                                                                  IDELH2
     20                                                                  IDELH3
      3      7      2.35         1.5                                     IDELH3
      3      7      9.15         1.75                                    IDELH3
      3      7      5.49         1.75                                    IDELH3
     20                                                                  IDELH3
     15                                                                  IDELH3
 12.          12.          12.          12.          13.          14.    HPD
 15.          16.          17.          18.          19.          20.    HPD
 21.          22.          23.                                          HPD
 99.5         -9.5                                                      HTLN
 1743858.     290643.      5503250.                                     LOAD
 894.         149.         470000.                                      WDOT.F
 162.9        37.          168.         38.5         3.                 TENIN
 0.           .2           .4           .6           .8           1.    TIMEA
 1.2          1.4          1.6          1.8          2.           2.2   TIMEA
 2.4          2.6          2.8          3.           3.2          3.4   TIMEA
 3.6          3.8          4.                                           TIMEA
 0.           0.           .005         .01          .02          .085  WDTFRO
 .082         .08          .08          .1           .17          .318  WDTFRO
 .466         .614         .762         .91          1.01         1.02  WDTFRO
 1.02         1.02         1.02                                         WDTFRO
 0.           .006         .013         .026         .047         .081  WDTFRH
 .165         .263         .246         .26          .294         .42   WDTFRH
 .51          .7           .893         .996         .999         1.    WDTFRH
 1.           1.           1.                                           WDTFRH
 0.           0.           .005         .01          .02          .085  FIFRAC
 .082         .08          .08          .1           .17          .318  FIFRAC
 .466         .614         .762         .91          1.01         1.02  FIFRAC
 1.02         1.02         1.02                                         FIFRAC
 8.           8.           8.           8.           8.           8.    NPSPO
 8.           8.           8.           8.           8.           8.    NPSPO
 8.           8.           8.           8.           8.           8.    NPSPO
 8.           8.           8.                                           NPSPO
 2.           2.           2.           2.           2.           2.    NPSPH
 2.           2.           2.           2.           2.           2.    NPSPH
 2.           2.           2.           2.           2.           2.    NPSPH
 2.           2.           2.                                           NPSPH
 25.          25.          25.          25.          25.          25.   PENMNO
 25.          25.          25.          25.          25.          25.   PENMNO
 25.          25.          25.          25.          25.          25.   PENMNO
 25.          25.          25.                                          PENMNO
 20.          20.          20.          20.          20.          20.   PENMNH
 20.          20.          20.          20.          20.          20.   PENMNH
 20.          20.          20.          20.          20.          20.   PENMNH
 20.          20.          20.                                          PENMNH
 0.           0.           0.           0.           0.           0.    PPDGOT
```

Table 2-3

SOPSA INPUT DATA LISTING (CONT'D)

0.	0.	0.	0.	0.	0.	PPDGOT
0.	0.	0.	0.	0.	0.	PPDGCT
0.	0.	0.				PPDGCT
0.	0.	0.	0.	0.	0.	PPDGHT
0.	0.	0.	0.	0.	0.	PPDGHT
0.	0.	0.	0.	0.	0.	PPDGHT
0.	0.	0.				PPDGHT
190.	190.	190.	190.	190.	190.	TDGOT
190.	190.	190.	190.	190.	190.	TDGOT
190.	190.	190.	190.	190.	190.	TDGOT
190.	190.	190.				TDGOT
60.	60.	60.	60.	60.	60.	TDGHT
60.	60.	60.	60.	60.	60.	TDGHT
60.	60.	60.	60.	60.	60.	TDGHT
60.	60.	60.				TDGHT
1						IGOON
SAMPLE CASE - ORBITER 040A, HIGH PENMN						TITLE
0000000000001001						DATAFLGS
60.	60.	60.	60.	60.	60.	PENMNO
60.	60.	60.	60.	60.	60.	PENMNO
60.	60.	60.	60.	60.	60.	PENMNO
60.	60.	60.				PENMNO
30.	30.	30.	30.	30.	30.	PENMNH
30.	30.	30.	30.	30.	30.	PENMNH
30.	30.	30.	30.	30.	30.	PENMNH
30.	30.	30.				PENMNH
0						IGOON

Table 2-4

SOPSA OUTPUT DATA LISTING

```
                SAMPLE CASE - ORBITER 040A, LOW PENMN

        INPUT DATA FOR START TRANSIENT PROBLEM CONSIDERED IN THIS ANALYSIS,

    THE NUMBER OF LINE SIZES TO BE CONSIDERED IS      15
    THE PROBLEM CONSIDERS BOTH OXIDIZER AND FUEL FEED SYSTEMS
    THE NUMBER OF ENGINES FOR THE VEHICLE IS      3
    THE NUMBER OF ENGINES FOR EACH FEED SYSTEM IS      3
    THE NOMINAL OXIDIZER FLOW RATE IS  894,00 LBS/SEC
    THE NOMINAL FUEL FLOW RATE IS  149,00 LBS/SEC
    THE VEHICLE LOADED WEIGHT IS  3503250,00 LBS
    THE NOMINAL THRUST FOR EACH ENGINE IS 470000,00 LBS
    THE BULK OXID, ENGINE INLET TEMPERATURE IS  162,90 DEG,R
    THE BULK FUEL ENGINE INLET TEMPERATURE IS  37,00 DEG,R
    THE COMPONENT PRESSURE TOLERANCE IS  3,00 PSI
    THE OXID, HEAD HEIGHT IN THE TANK IS  51,784 FT
    THE OXID, HEAD HEIGHT IN THEFEED LINE IS  99,500 FT
    THE FUEL HEAD HEIGHT IN THE TANK IS  96,186 FT
    THE FUEL HEAD HEIGHT IN THE FEED LINE IS  =9,500FT
    THE INITIAL ULLAGE VOLUME IN THE OXIDIZER TANK IS      608,CU,FT
    THE INITIAL ULLAGE VOLUME IN THE FUEL TANK IS      1784, CU,FT
    THE INITIAL OXIDIZER LOADING IS  1743858, LBS
    THE INITIAL FUEL LOADING IS      290643, LBS
    THE EXTERNAL SURFACE AREA OF THE DROP TANK IS      13653,1 SQ, FT,
    THE EXTERNAL SURFACE AREA OF THE LOX/LH2 BULKHEAD IS  1160,2 SQ, FT,
    THE TOTAL SURFACE AREA IS THEREFORE      14813,4 SQ, FT,
    THE OXYGEN FEEDLINE DESIGN PRESSURE IS ,00000000    PSI
    THE HYDROGEN FEEDLINE DESIGN PRESSURE IS ,00000000    PSI
```

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

THE TANK GEOMETRY INPUT VALUES ARE AS FOLLOWS = ,

L1= 120,000 L2= 549,000 L3= 551,000 L4=1691,000 R1= 120,000 R2= 120,000 R3= 128,000 R4= 181,000 R5= 128,000

TABLE OF FEED LINE DATA

OXIDIZER LINES			FUEL LINES		
DIAMETER INCHES	LENGTH FEET	K-FACTOR	DIAMETER INCHES	LENGTH FEET	K-FACTOR
12,00	6,80	,4143	12,00	7,14	,4073
12,00	12,43	,5499	12,00	11,85	,6388
12,00	16,01	,6353	12,00	19,99	,8469
12,00	143,00	3,0925	12,00	39,00	1,4212
13,00	143,00	2,9399	13,00	39,00	1,3022
14,00	143,00	2,6095	14,00	39,00	1,3493
15,00	143,00	2,6970	15,00	39,00	1,3214
16,00	143,00	2,5991	16,00	39,00	1,2975
17,00	143,00	2,5133	17,00	39,00	1,2769
18,00	143,00	2,4375	18,00	39,00	1,2591
19,00	143,00	2,3702	19,00	39,00	1,2436
20,00	143,00	2,3601	20,00	39,00	1,2302
21,00	143,00	2,3063	21,00	39,00	1,2185
22,00	143,00	2,2579	22,00	39,00	1,2083
23,00	143,00	2,2142	23,00	39,00	1,1994

COMPONENT DESCRIPTORS FOR MAIN OXYGEN FEEDLINE

COMPONENT	TYPE	MAT	INSUL	SPEC1	SPEC2	SPEC3
1	1	0	0	,0000	,0000	,0000
2	3	2	5	5,000	20,00	,7500
3	20	0	0	,0000	,0000	,0000
4	3	2	5	9,160	13,33	,7500
5	20	0	0	,0000	,0000	,0000
6	3	2	5	4,160	8,330	,7500
7	2	2	5	7,000	,0000	,7500
8	22	0	0	,0000	,0000	,0000
9	2	2	5	72,00	,0000	,7500
10	22	0	0	,0000	,0000	,0000
11	2	2	5	4,000	,0000	,7500
12	3	2	5	4,100	1,750	,7500
13	3	2	5	1,380	1,750	,7500
14	2	2	5	4,000	,0000	,7500
15	15	0	0	,0000	,0000	,0000
16	20	0	0	,0000	,0000	,0000
17	3	2	5	1,000	1,270	,7500
18	20	0	0	,0000	,0000	,0000
19	2	2	5	1,500	,0000	,7500
20	16	0	0	,0000	,0000	,0000
21	3	2	5	4,000	7,650	,7500
22	15	0	0	,0000	,0000	,0000
23	20	0	0	,0000	,0000	,0000

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

24	2	2	5	7,000	,0000	,7500
25	20	0	0	,0000	,0000	,0000
26	8	2	5	1,000	1,500	,7500

COMPONENT DESCRIPTORS FOR ENGINE OXYGEN FEEDLINE NUMBER 1

COMPONENT	TYPE	MATL	INSUL	SPEC1	SPEC2	SPEC3
1	20	0	0	,0000	,0000	,0000
2	3	2	5	3,800	1,500	,7500
3	20	0	0	,0000	,0000	,0000
4	15	0	0	,0000	,0000	,0000

COMPONENT DESCRIPTORS FOR ENGINE OXYGEN FEEDLINE NUMBER 2

COMPONENT	TYPE	MATL	INSUL	SPEC1	SPEC2	SPEC3
1	20	0	0	,0000	,0000	,0000
2	3	2	5	5,500	1,750	,7500
3	3	2	5	3,930	2,500	,7500
4	20	0	0	,0000	,0000	,0000
5	15	0	0	,0000	,0000	,0000

COMPONENT DESCRIPTORS FOR ENGINE OXYGEN FEEDLINE NUMBER 3

COMPONENT	TYPE	MATL	INSUL	SPEC1	SPEC2	SPEC3
1	20	0	0	,0000	,0000	,0000
2	3	2	5	4,710	2,000	,7500
3	3	2	5	1,500	2,860	,7500
4	2	2	5	3,000	,0000	,7500
5	3	2	5	3,800	1,500	,7500
6	20	0	0	,0000	,0000	,0000
7	15	0	0	,0000	,0000	,0000

COMPONENT DESCRIPTORS FOR MAIN HYDROGEN FEEDLINE

COMPONENT	TYPE	MATL	INSUL	SPEC1	SPEC2	SPEC3
1	1	0	0	,0000	,0000	,0000
2	2	7	0	1,000	,0000	,0000
3	20	0	0	,0000	,0000	,0000
4	3	7	0	9,440	12,00	,0000
5	20	0	0	,0000	,0000	,0000
6	3	7	0	9,440	12,00	,0000
7	20	0	0	,0000	,0000	,0000
8	15	0	0	,0000	,0000	,0000
9	3	7	0	2,750	1,750	,0000
10	16	0	0	,0000	,0000	,0000
11	3	7	0	,9200	1,750	,0000
12	15	0	0	,0000	,0000	,0000
13	20	0	0	,0000	,0000	,0000
14	2	7	0	3,750	,0000	,0000

COMPONENT DESCRIPTORS FOR ENGINE HYDROGEN FEEDLINE NUMBER 1

COMPONENT	TYPE	MATL	INSUL	SPEC1	SPEC2	SPEC3

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

1	8	7	0	1,000	1,350	,0000
2	20	0	0	,0000	,0000	,0000
3	3	7	0	3,140	1,500	,0000
4	20	0	0	,0000	,0000	,0000
5	15	0	0	,0000	,0000	,0000

COMPONENT DESCRIPTORS FOR ENGINE HYDROGEN FEEDLINE NUMBER 2

COMPONENT	TYPE	MATL	INSUL	SPEC1	SPEC2	SPEC3
1	3	7	0	2,350	1,500	,0000
2	4	7	0	7,500	1,500	,0000
3	20	0	0	,0000	,0000	,0000
4	15	0	0	,0000	,0000	,0000

COMPONENT DESCRIPTORS FOR ENGINE HYDROGEN FEEDLINE NUMBER 3

COMPONENT	TYPE	MATL	INSUL	SPEC1	SPEC2	SPEC3
1	20	0	0	,0000	,0000	,0000
2	3	7	0	2,350	1,500	,0000
3	3	7	0	9,150	1,750	,0000
4	3	7	0	5,490	1,750	,0000
5	20	0	0	,0000	,0000	,0000
6	15	0	0	,0000	,0000	,0000

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

THE TIME DEPENDENT PERFORMANCE CHARACTERISTIC INPUT VALUES ARE AS FOLLOWS = ,

TIME	NPSPO	NPSPH	WDTFRO	WDTFRH	FIFRAC	PENMNO	PENMNH	PPDGOT	PPDGHT	TDGOT	TDGHT
,00	8,00	2,00	,000	,000	.000	25,00	20,00	,00	,00	190,00	60,00
,20	8,00	2,00	,000	,006	.000	25,00	20,00	,00	,00	190,00	60,00
,40	8,00	2,00	,005	,013	.005	25,00	20,00	,00	,00	190,00	60,00
,60	8,00	2,00	,010	,026	.010	25,00	20,00	,00	,00	190,00	60,00
,80	8,00	2,00	,020	,047	.020	25,00	20,00	,00	,00	190,00	60,00
1,00	8,00	2,00	,085	,081	.085	25,00	20,00	,00	,00	190,00	60,00
1,20	8,00	2,00	,082	,165	.082	25,00	20,00	,00	,00	190,00	60,00
1,40	8,00	2,00	,080	,263	.080	25,00	20,00	,00	,00	190,00	60,00
1,60	8,00	2,00	,080	,246	.080	25,00	20,00	,00	,00	190,00	60,00
1,80	8,00	2,00	,100	,260	.100	25,00	20,00	,00	,00	190,00	60,00
2,00	8,00	2,00	,170	,294	.170	25,00	20,00	,00	,00	190,00	60,00
2,20	8,00	2,00	,318	,420	.318	25,00	20,00	,00	,00	190,00	60,00
2,40	8,00	2,00	,466	,510	.466	25,00	20,00	,00	,00	190,00	60,00
2,60	8,00	2,00	,614	,700	.614	25,00	20,00	,00	,00	190,00	60,00
2,80	8,00	2,00	,762	,893	.762	25,00	20,00	,00	,00	190,00	60,00
3,00	8,00	2,00	,910	,996	.910	25,00	20,00	,00	,00	190,00	60,00
3,20	8,00	2,00	1,010	,999	1.010	25,00	20,00	,00	,00	190,00	60,00
3,40	8,00	2,00	1,020	1,000	1.020	25,00	20,00	,00	,00	190,00	60,00
3,60	8,00	2,00	1,020	1,000	1.020	25,00	20,00	,00	,00	190,00	60,00
3,80	8,00	2,00	1,020	1,000	1.020	25,00	20,00	,00	,00	190,00	60,00
4,00	8,00	2,00	1,020	1,000	1.020	25,00	20,00	,00	,00	190,00	60,00

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, LOW PENMN

TRANS. TIME	WDDOT OXID.	WDDOT FUEL	VEHICLE WEIGHT	T/W RATIO	DELPHD OXID.	DELPHD FUEL	PROP-O INCR	PROP-F INCR	PROP-TOT CUM	PENO OXID	PENO FUEL
.00	.000	4.470	5503249.75	1.000	74.49	2.65	.000	.268	.268	25.00	20.00
.20	22.350	5.215	5503247.56	1.000	74.49	2.65	1.341	.849	2.458	25.00	20.00
.40	22.350	9.685	5503241.81	1.000	74.49	2.65	4.023	1.743	8.225	25.00	20.00
.60	44.700	15.645	5503230.56	1.000	74.49	2.65	8.046	3.263	19.534	25.00	20.00
.80	290.550	25.330	5503196.69	1.000	74.49	2.65	28.161	5.722	53.416	25.00	20.00
1.00	-13.410	62.580	5503140.94	1.000	74.48	2.65	44.789	10.996	109.202	25.00	20.00
1.20	-8.940	73.010	5503078.37	1.000	74.48	2.65	63.448	19.132	171.782	25.00	20.00
1.40	.000	-12.665	5503012.75	1.000	74.48	2.65	82.912	22.752	237.446	25.00	20.00
1.60	89.400	10.430	5502941.87	1.000	74.48	2.65	98.276	22.618	308.341	25.00	20.00
1.80	312.900	25.330	5502844.75	1.000	74.48	2.64	72.414	24.764	405.518	25.00	20.00
2.00	661.560	93.870	5502682.00	1.000	74.47	2.64	130.882	31.916	568.316	25.00	20.00
2.20	661.560	67.050	5502430.19	1.000	74.47	2.64	210.269	41.571	820.156	25.00	20.00
2.40	661.560	141.550	5502086.50	1.000	74.46	2.64	289.696	54.087	1163.899	25.00	20.00
2.60	661.560	143.785	5501646.25	1.000	74.45	2.64	369.043	71.207	1604.149	25.00	20.00
2.80	661.560	76.735	5501113.44	1.000	74.43	2.64	448.430	84.438	2137.018	25.00	20.00
3.00	447.000	2.235	5500509.37	1.000	74.42	2.64	514.944	89.176	2741.138	25.00	20.00
3.20	44.700	.745	5499875.62	1.000	74.40	2.64	544.446	89.355	3374.939	25.00	20.00
3.40	.000	.000	5499239.12	1.000	74.39	2.64	547.128	89.400	4011.467	25.00	20.00
3.60	.000	.000	5498602.62	1.000	74.37	2.64	547.128	89.400	4647.995	25.00	20.00
3.80	.000	.000	5497966.12	1.000	74.35	2.64	547.128	89.400	5284.523	25.00	20.00
4.00											

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE = ORBITER 040A, LOW PENMN = OXYGEN SUPPLY SYSTEM

DELTA-P TO SUPPLY ACCELERATION HEAD

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
.20	2.635	2.245	1.936	1.686	1.482	1.313	1.171	1.051	.949	.860	.784	.717
.40	2.635	2.245	1.936	1.686	1.482	1.313	1.171	1.051	.949	.860	.784	.717
.60	5.270	4.491	3.872	3.373	2.965	2.626	2.342	2.102	1.897	1.721	1.568	1.435
.80	34.257	29.189	25.168	21.924	19.269	17.069	15.225	13.665	12.332	11.186	10.192	9.325
1.00	-1.581	-1.347	-1.162	-1.012	-.889	-.788	-.703	-.631	-.569	-.516	-.470	-.430
1.20	-1.054	-.898	-.774	-.675	-.593	-.525	-.468	-.420	-.379	-.344	-.314	-.287
1.40	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
1.60	10.541	8.981	7.744	6.746	5.929	5.252	4.685	4.205	3.795	3.442	3.136	2.869
1.80	36.892	31.435	27.104	23.611	20.752	18.382	16.396	14.716	13.281	12.046	10.976	10.042
2.00	78.000	66.462	57.306	49.920	43.875	38.865	34.667	31.114	28.080	25.469	23.207	21.233
2.20	78.000	66.462	57.306	49.920	43.875	38.865	34.667	31.114	28.080	25.469	23.207	21.233
2.40	78.000	66.462	57.306	49.920	43.875	38.865	34.667	31.114	28.080	25.469	23.207	21.233
2.60	78.000	66.462	57.306	49.920	43.875	38.865	34.667	31.114	28.080	25.469	23.207	21.233
2.80	78.000	66.462	57.306	49.920	43.875	38.865	34.667	31.114	28.080	25.469	23.207	21.233
3.00	52.703	44.907	38.720	33.730	29.645	26.260	23.424	21.023	18.973	17.209	15.680	14.346
3.20	5.270	4.491	3.872	3.373	2.965	2.626	2.342	2.102	1.897	1.721	1.568	1.435
3.40	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
3.60	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
3.80	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, LOW PENMN - HYDROGEN SUPPLY SYSTEM

DELTAP TO SUPPLY ACCELERATION HEAD

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00												
.20	.144	.122	.106	.092	.081	.072	.064	.057	.052	.047	.043	.039
.40	.168	.143	.123	.107	.094	.084	.075	.067	.060	.055	.050	.046
.60	.311	.265	.229	.199	.175	.155	.138	.124	.112	.102	.093	.085
.80	.503	.429	.370	.322	.283	.251	.224	.201	.181	.164	.150	.137
1.00	.814	.694	.598	.521	.458	.406	.362	.325	.293	.266	.242	.222
1.20	2.012	1.715	1.478	1.288	1.132	1.003	.894	.803	.724	.657	.599	.548
1.40	2.348	2.000	1.725	1.503	1.321	1.170	1.043	.936	.845	.767	.698	.639
1.60	-.407	-.347	-.299	-.261	-.229	-.203	-.181	-.162	-.147	-.133	-.121	-.111
1.80	.335	.286	.246	.215	.189	.167	.149	.134	.121	.110	.100	.091
2.00	.814	.694	.598	.521	.458	.406	.362	.325	.293	.266	.242	.222
2.20	3.018	2.572	2.218	1.932	1.698	1.504	1.342	1.204	1.087	.986	.898	.822
2.40	2.156	1.837	1.584	1.380	1.213	1.074	.958	.860	.776	.704	.641	.587
2.60	4.552	3.878	3.344	2.913	2.560	2.268	2.023	1.816	1.639	1.486	1.354	1.239
2.80	4.623	3.940	3.397	2.959	2.601	2.304	2.055	1.844	1.664	1.510	1.376	1.259
3.00	2.467	2.102	1.813	1.579	1.388	1.229	1.097	.984	.888	.806	.734	.672
3.20	.072	.061	.053	.046	.040	.036	.032	.029	.026	.023	.021	.020
3.40	.024	.020	.018	.015	.013	.012	.011	.010	.009	.008	.007	.007
3.60	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
3.80	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
4.00	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE = ORBITER 040A, LOW PENMN = OXYGEN SUPPLY SYSTEM

DELTA-P DUE TO LINE FRICTION AND CONFIGURATION LOSSES

DELTA TIME	12,0 INCH MAIN LINE	13,0 INCH MAIN LINE	14,0 INCH MAIN LINE	15,0 INCH MAIN LINE	16,0 INCH MAIN LINE	17,0 INCH MAIN LINE	18,0 INCH MAIN LINE	19,0 INCH MAIN LINE	20,0 INCH MAIN LINE	21,0 INCH MAIN LINE	22,0 INCH MAIN LINE	23,0 INCH MAIN LINE
,00	,0000	,0000	,0000	,0000	,0000	,0000	,0000	,0000	,0000	,0000	,0000	,0000
,20	,3431-03	,2368-03	,1682-03	,1226-03	,9124-04	,6923-04	,5342-04	,4184-04	,3393-04	,2728-04	,2217-04	,1820-04
,40	,3088-02	,2131-02	,1514-02	,1103-02	,8211-03	,6230-03	,4807-03	,3766-03	,3054-03	,2455-03	,1996-03	,1638-03
,60	,1235-01	,8525-02	,6057-02	,4412-02	,3285-02	,2492-02	,1923-02	,1506-02	,1222-02	,9821-03	,7983-03	,6553-03
,80	,1513+00	,1044+00	,7420-01	,5405-01	,4024-01	,3053-01	,2356-01	,1845-01	,1497-01	,1203-01	,9779-02	,8027-02
1,00	,3027+00	,2642+00	,1877+00	,1367+00	,1018+00	,7723-01	,5959-01	,4667-01	,3786-01	,3043-01	,2474-01	,2031-01
1,20	,3602+00	,2486+00	,1766+00	,1287+00	,9578-01	,7267-01	,5607-01	,4392-01	,3562-01	,2864-01	,2328-01	,1911-01
1,40	,3513+00	,2425+00	,1723+00	,1255+00	,9343-01	,7089-01	,5470-01	,4284-01	,3475-01	,2794-01	,2271-01	,1864-01
1,60	,4446+00	,3069+00	,2180+00	,1588+00	,1182+00	,8972-01	,6923-01	,5422-01	,4398-01	,3536-01	,2874-01	,2359-01
1,80	,1000+01	,6905+00	,4906+00	,3574+00	,2660+00	,2019+00	,1558+00	,1220+00	,9895-01	,7955-01	,6466-01	,5308-01
2,00	,3268+01	,2256+01	,1603+01	,1167+01	,8691+00	,6594+00	,5088+00	,3986+00	,3233+00	,2599+00	,2112+00	,1734+00
2,20	,8435+01	,5822+01	,4137+01	,3013+01	,2243+01	,1702+01	,1313+01	,1029+01	,8343+00	,6707+00	,5452+00	,4475+00
2,40	,1601+02	,1105+02	,7850+01	,5718+01	,4257+01	,3230+01	,2492+01	,1952+01	,1583+01	,1273+01	,1035+01	,8493+00
2,60	,2598+02	,1793+02	,1274+02	,9282+01	,6910+01	,5243+01	,4045+01	,3169+01	,2570+01	,2066+01	,1679+01	,1379+01
2,80	,3837+02	,2648+02	,1881+02	,1371+02	,1020+02	,7741+01	,5973+01	,4679+01	,3795+01	,3051+01	,2480+01	,2035+01
3,00	,5059+02	,3492+02	,2481+02	,1807+02	,1345+02	,1021+02	,7877+01	,6170+01	,5004+01	,4023+01	,3270+01	,2684+01
3,20	,5655+02	,3903+02	,2773+02	,2020+02	,1504+02	,1141+02	,8805+01	,6897+01	,5594+01	,4497+01	,3655+01	,3000+01
3,40	,5711+02	,3942+02	,2801+02	,2040+02	,1519+02	,1152+02	,8892+01	,6965+01	,5649+01	,4541+01	,3691+01	,3030+01
3,60	,5711+02	,3942+02	,2801+02	,2040+02	,1519+02	,1152+02	,8892+01	,6965+01	,5649+01	,4541+01	,3691+01	,3030+01
3,80	,5711+02	,3942+02	,2801+02	,2040+02	,1519+02	,1152+02	,8892+01	,6965+01	,5649+01	,4541+01	,3691+01	,3030+01
4,00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, LOW PENMN - HYDROGEN SUPPLY SYSTEM

DELTA-P DUE TO LINE FRICTION AND CONFIGURATION LOSSES

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	.1017-03	.7183-04	.5213-04	.3874-04	.2938-04	.2269-04	.1780-04	.1416-04	.1141-04	.9299-05	.7655-05	.6361-05
.20	.1020-02	.7202-03	.5227-03	.3885-03	.2946-03	.2275-03	.1785-03	.1420-03	.1144-03	.9325-04	.7677-04	.6379-04
.40	.4298-02	.3035-02	.2202-02	.1637-02	.1241-02	.9586-03	.7521-03	.5984-03	.4821-03	.3929-03	.3234-03	.2688-03
.60	.1506-01	.1063-01	.7717-02	.5734-02	.4349-02	.3359-02	.2635-02	.2096-02	.1689-02	.1376-02	.1133-02	.9416-03
.80	.4629-01	.3269-01	.2372-01	.1763-01	.1337-01	.1033-01	.8101-02	.6446-02	.5193-02	.4232-02	.3484-02	.2895-02
1.00	.1710+00	.1207+00	.8763-01	.6512-01	.4939-01	.3814-01	.2992-01	.2381-01	.1918-01	.1563-01	.1287-01	.1069-01
1.20	.5176+00	.3655+00	.2653+00	.1971+00	.1495+00	.1155+00	.9058-01	.7207-01	.5806-01	.4732-01	.3895-01	.3237-01
1.40	.7321+00	.5169+00	.3752+00	.2788+00	.2115+00	.1633+00	.1281+00	.1019+00	.8212-01	.6692-01	.5509-01	.4578-01
1.60	.7235+00	.5108+00	.3707+00	.2755+00	.2090+00	.1614+00	.1266+00	.1007+00	.8116-01	.6613-01	.5445-01	.4524-01
1.80	.8672+00	.6123+00	.4444+00	.3303+00	.2505+00	.1934+00	.1518+00	.1207+00	.9728-01	.7928-01	.6526-01	.5423-01
2.00	.1440+01	.1017+01	.7382+00	.5486+00	.4161+00	.3213+00	.2521+00	.2006+00	.1616+00	.1317+00	.1084+00	.9008-01
2.20	.2444+01	.1726+01	.1252+01	.9307+00	.7059+00	.5451+00	.4277+00	.3403+00	.2742+00	.2234+00	.1839+00	.1528+00
2.40	.4137+01	.2921+01	.2120+01	.1575+01	.1195+01	.9228+00	.7239+00	.5760+00	.4641+00	.3782+00	.3113+00	.2587+00
2.60	.7170+01	.5063+01	.3675+01	.2731+01	.2071+01	.1599+01	.1255+01	.9983+00	.8044+00	.6555+00	.5396+00	.4484+00
2.80	.1008+02	.7119+01	.5167+01	.3840+01	.2912+01	.2249+01	.1764+01	.1404+01	.1131+01	.9217+00	.7588+00	.6305+00
3.00	.1125+02	.7941+01	.5763+01	.4283+01	.3248+01	.2508+01	.1968+01	.1566+01	.1262+01	.1028+01	.8463+00	.7033+00
3.20	.1129+02	.7973+01	.5786+01	.4300+01	.3261+01	.2519+01	.1976+01	.1572+01	.1267+01	.1032+01	.8497+00	.7061+00
3.40	.1130+02	.7981+01	.5792+01	.4304+01	.3265+01	.2521+01	.1978+01	.1574+01	.1268+01	.1033+01	.8506+00	.7068+00
3.60	.1130+02	.7981+01	.5792+01	.4304+01	.3265+01	.2521+01	.1978+01	.1574+01	.1268+01	.1033+01	.8506+00	.7068+00
3.80	.1130+02	.7981+01	.5792+01	.4304+01	.3265+01	.2521+01	.1978+01	.1574+01	.1268+01	.1033+01	.8506+00	.7068+00
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, LOW PENMN -OXYGEN ENGINE FEEDLINE SYSTEM

DELTA TIME	DELTA-P TO SUPPLY ACCELERATION HEAD				DELTA-P DUE TO LINE FRICTION AND CONFIGURATION LOSSES			
	ENGINE LINE NO 1	ENGINE LINE NO 2	ENGINE LINE NO 3	ENGINE LINE NO 4	ENGINE LINE NO 1	ENGINE LINE NO 2	ENGINE LINE NO 3	ENGINE LINE NO 4
,00	,00000000	,00000000	,00000000	,00000000	,00000000	,00000000	,00000000	,00000000
,20	,41769110-01	,76351536-01	,98341784-01	,00000000	,21065396-05	,67791624-05	,78310665-05	,00000000
,40	,41769109-01	,76351536-01	,98341782-01	,00000000	,45958857-04	,61012462-04	,70479599-04	,00000000
,60	,83538221-01	,15270308	,19668357	,00000000	,18383543-03	,24404985-03	,28191840-03	,00000000
,80	,54299843	,99256998	1,2784432	,00000000	,22519839-02	,29896106-02	,34535003-02	,00000000
1,00	-,25061462-01	-,45810915-01	-,59005060-01	,00000000	,56966513-02	,75625624-02	,87360246-02	,00000000
1,20	-,16707646-01	-,30540619-01	-,39336719-01	,00000000	,53606410-02	,71164935-02	,82207404-02	,00000000
1,40	,00000000	,00000000	,00000000	,00000000	,52290966-02	,69418623-02	,80190120-02	,00000000
1,60	,16707643	,30540613	,39336711	,00000000	,66180752-02	,87857944-02	,10149062-01	,00000000
1,80	,58476748	1,0689214	1,3767848	,00000000	,14890669-01	,19768038-01	,22835390-01	,00000000
2,00	1,2363657	2,2600056	2,9109170	,00000000	,48643671-01	,64576673-01	,74596860-01	,00000000
2,20	1,2363655	2,2600053	2,9109165	,00000000	,12555061	,16667411	,19253648	,00000000
2,40	1,2363657	2,2600056	2,9109170	,00000000	,23825071	,31628860	,36536624	,00000000
2,60	1,2363655	2,2600053	2,9109165	,00000000	,38674399	,51342013	,59308614	,00000000
2,80	1,2363657	2,2600055	2,9109168	,00000000	,57103042	,75806872	,87569617	,00000000
3,00	,83538232	1,5270310	1,9668359	,00000000	,75298991	,99962818	1,1547378	,00000000
3,20	,83538133-01	,15270291	,19668336	,00000000	,84174157	1,1174500	1,2908417	,00000000
3,40	,00000000	,00000000	,00000000	,00000000	,85005499	1,1284865	1,3033906	,00000000
3,60	,00000000	,00000000	,00000000	,00000000	,85005499	1,1284865	1,3035906	,00000000
3,80	,00000000	,00000000	,00000000	,00000000	,85005499	1,1284865	1,3035906	,00000000
4,00								

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER D40A, LOW PENMN -HYDROGEN ENGINE FEEDLINE SYSTEM

	DELTA-P TO SUPPLY ACCELERATION HEAD				DELTA-P DUE TO LINE FRICTION AND CONFIGURATION LOSSES			
DELTA TIME	ENGINE LINE NO 1	ENGINE LINE NO 2	ENGINE LINE NO 3	ENGINE LINE NO 4	ENGINE LINE NO 1	ENGINE LINE NO 2	ENGINE LINE NO 3	ENGINE LINE NO 4
,00	,87715138-02	,14557779-01	,24557809-01	,00000000	,32394354-05	,50801058-05	,67352826-05	,00000000
,20	,10233433-01	,16984076-01	,28650777-01	,00000000	,32484338-04	,50942172-04	,67539917-04	,00000000
,40	,19004946-01	,31541854-01	,53208584-01	,00000000	,13686614-03	,21463447-03	,28456569-03	,00000000
,60	,30700298-01	,50952227-01	,85952330-01	,00000000	,47952643-03	,75199678-03	,99700893-03	,00000000
,80	,49705245-01	,82494083-01	,13916092	,00000000	,14743030-02	,23120126-02	,30653019-02	,00000000
1,00	,12280119	,20380890	,34380931	,00000000	,54454909-02	,85396580-02	,11322010-01	,00000000
1,20	,14326806	,23777706	,40111087	,00000000	,16483687-01	,25849836-01	,34272112-01	,00000000
1,40	-,24852625-01-	,41247046-01-	,69580465-01	,00000000	,23313226-01	,36559969-01	,48471770-01	,00000000
1,60	,20466868-01	,33968156-01	,57301561-01	,00000000	,23039224-01	,36130277-01	,47902078-01	,00000000
1,80	,49705238-01	,82494070-01	,13916090	,00000000	,27617627-01	,43310160-01	,57421277-01	,00000000
2,00	,18420180	,30571339	,51571401	,00000000	,45873645-01	,71939379-01	,95378337-01	,00000000
2,20	,13157269	,21836666	,36836708	,00000000	,77827437-01	,12204954	,16181517	,00000000
2,40	,27776463	,46099638	,77766400	,00000000	,13174604	,20660508	,27392020	,00000000
2,60	,28215033	,46827518	,78994275	,00000000	,22834861	,35809793	,47477176	,00000000
2,80	,15057766	,24990856	,42157574	,00000000	,32109293	,50354023	,66760140	,00000000
3,00	,43857551-02	,72788867-02	,12278899-01	,00000000	,35813983	,56163745	,74462758	,00000000
3,20	,14619218-02	,24263012-02	,40929760-02	,00000000	,35957742	,56389189	,74761655	,00000000
3,40	,00000000	,00000000	,00000000	,00000000	,35993727	,56445621	,74836475	,00000000
3,60	,00000000	,00000000	,00000000	,00000000	,35993727	,56445621	,74836475	,00000000
3,80	,00000000	,00000000	,00000000	,00000000	,35993727	,56445621	,74836475	,00000000
4,00								

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, LOW PENMN - OXYGEN SUPPLY SYSTEM

ULLAGE PRESSURE REQUIRED FOR 3 ENGINE OPERATION

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
,00	-46,486	-46,486	-46,486	-46,486	-46,486	-46,486	-46,486	-46,486	-46,486	-46,486	-46,486	-46,486
,20	-43,753	-44,142	-44,452	-44,701	-44,906	-45,075	-45,217	-45,337	-45,439	-45,528	-45,604	-45,671
,40	-43,750	-44,140	-44,450	-44,700	-44,905	-45,074	-45,216	-45,336	-45,439	-45,527	-45,604	-45,670
,60	-41,006	-41,790	-42,411	-42,912	-43,321	-43,661	-43,945	-44,185	-44,391	-44,567	-44,720	-44,854
,80	-10,795	-15,910	-19,961	-23,225	-25,894	-28,104	-29,954	-31,520	-32,856	-34,005	-35,001	-35,870
1,00	-47,682	-47,567	-47,458	-47,359	-47,271	-47,194	-47,127	-47,068	-47,015	-46,970	-46,929	-46,894
1,20	-47,176	-47,132	-47,080	-47,028	-46,980	-46,935	-46,895	-46,859	-46,826	-46,798	-46,773	-46,750
1,40	-46,122	-46,231	-46,301	-46,348	-46,380	-46,402	-46,418	-46,430	-46,438	-46,445	-46,450	-46,455
1,60	-35,091	-36,788	-38,114	-39,171	-40,029	-40,734	-41,322	-41,817	-42,238	-42,599	-42,911	-43,183
1,80	-7,185	-12,953	-17,483	-21,110	-24,060	-26,494	-28,526	-30,240	-31,698	-32,952	-34,037	-34,982
2,00	37,780	25,229	15,421	7,600	1,256	-3,963	-8,312	-11,976	-15,085	-17,759	-20,070	-22,082
2,20	43,072	28,920	18,079	9,570	2,755	-2,797	-7,384	-11,221	-14,449	-17,224	-19,612	-21,684
2,40	50,825	34,328	21,974	12,456	4,950	-1,087	-6,023	-10,117	-13,519	-16,440	-18,941	-21,100
2,60	61,041	41,452	27,105	16,259	7,842	1,165	-4,231	-8,661	-12,293	-15,408	-18,057	-20,332
2,80	73,718	50,294	33,473	20,978	11,430	3,959	-2,007	-6,855	-10,773	-14,127	-16,961	-19,379
3,00	59,996	36,527	20,232	8,505	-,198	-6,829	-11,997	-16,105	-19,320	-22,065	-24,347	-26,267
3,20	16,909	-1,391	-13,310	-21,340	-26,911	-30,878	-33,768	-35,916	-37,424	-38,697	-39,692	-40,480
3,40	12,029	-5,664	-17,076	-24,681	-29,895	-33,559	-36,191	-38,118	-39,434	-40,541	-41,392	-42,053
3,60	12,045	-5,648	-17,060	-24,665	-29,879	-33,543	-36,175	-38,102	-39,418	-40,525	-41,376	-42,037
3,80	12,061	-5,632	-17,044	-24,649	-29,863	-33,527	-36,159	-38,086	-39,402	-40,509	-41,360	-42,021
4,00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, LOW PENMN - HYDROGEN SUPPLY SYSTEM

ULLAGE PRESSURE REQUIRED FOR 3 ENGINE OPERATION

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	20.522	20.501	20.484	20.470	20.459	20.450	20.442	20.436	20.430	20.425	20.421	20.417
.20	20.551	20.526	20.506	20.490	20.477	20.466	20.457	20.449	20.443	20.437	20.432	20.428
.40	20.723	20.676	20.638	20.608	20.584	20.563	20.546	20.532	20.520	20.509	20.500	20.492
.60	20.959	20.880	20.818	20.768	20.728	20.695	20.667	20.643	20.623	20.606	20.592	20.579
.80	21.357	21.223	21.118	21.035	20.968	20.912	20.866	20.827	20.794	20.766	20.742	20.721
1.00	22.892	22.544	22.275	22.062	21.890	21.750	21.633	21.536	21.453	21.382	21.321	21.268
1.20	23.655	23.155	22.780	22.489	22.260	22.075	21.924	21.798	21.693	21.603	21.527	21.461
1.40	20.679	20.524	20.430	20.373	20.337	20.315	20.302	20.294	20.290	20.288	20.288	20.289
1.60	21.519	21.257	21.077	20.950	20.858	20.788	20.736	20.694	20.662	20.636	20.614	20.596
1.80	22.233	21.858	21.594	21.403	21.260	21.151	21.065	20.997	20.942	20.897	20.859	20.828
2.00	25.425	24.556	23.922	23.447	23.080	22.792	22.560	22.371	22.215	22.084	21.973	21.878
2.20	25.486	24.449	23.723	23.197	22.805	22.506	22.272	22.086	21.936	21.814	21.711	21.626
2.40	30.097	28.208	26.872	25.897	25.163	24.599	24.135	23.800	23.511	23.273	23.074	22.906
2.60	33.416	30.625	28.694	27.312	26.294	25.525	24.932	24.465	24.091	23.787	23.537	23.329
2.80	33.998	30.669	28.428	26.867	25.748	24.926	24.309	23.836	23.467	23.175	22.941	22.750
3.00	32.434	29.118	26.932	25.445	24.405	23.661	23.116	22.711	22.404	22.168	21.984	21.839
3.20	32.427	29.105	26.916	25.428	24.387	23.643	23.099	22.694	22.388	22.152	21.969	21.825
3.40	32.412	29.091	26.902	25.414	24.375	23.631	23.088	22.684	22.378	22.143	21.961	21.817
3.60	32.413	29.092	26.903	25.415	24.376	23.632	23.089	22.685	22.379	22.144	21.962	21.818
3.80	32.414	29.093	26.904	25.416	24.377	23.633	23.090	22.686	22.380	22.145	21.963	21.819
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, LOW PENMN

PRESSURE AND VOLUME VALUES FOR FLUID VAPOR, MIN, ULLAGE, TANK BOTTOM, LINE HEAD, ULLAGE VOLUME, TANK HEAD HEIGHT AND ULLAGE WEIGHT

TRANS, TIME SEC	ULLVAP OXID, PSIA	ULLVAP FUEL PSIA	MINULL OXID, PSIA	MINULL FUEL PSIA	TNKBOT OXID, PSIA	TNKBOT FUEL PSIA	LINHED OXID, PSIA	LINHED FUEL PSIA	ULLVOL OXID, CU.FT.	ULLVOL FUEL CU.FT.	TNKHED OXID, FT.	TNKHED FUEL FT.	ULLWGT OXID, LBS	ULLWGT FUEL LBS
.00	20.052	20.170	20.05	20.52	45.55	23.46	48.99	.290	607.8	1784.5	51.78	96.19	209.6	149.4
.20	20.052	20.170	20.05	20.55	45.55	23.49	48.99	.290	607.8	1784.7	51.78	96.19	209.6	149.7
.40	20.052	20.170	20.05	20.72	45.55	23.66	48.99	.290	607.9	1785.1	51.78	96.18	209.7	151.0
.60	20.052	20.170	20.05	20.96	45.55	23.90	48.99	.290	608.0	1785.8	51.78	96.18	209.7	152.9
.80	20.052	20.170	20.05	21.36	45.55	24.29	48.99	.290	608.4	1787.1	51.78	96.18	209.8	156.1
1.00	20.052	20.170	20.05	22.89	45.55	25.83	48.99	.290	609.0	1789.6	51.78	96.18	210.1	168.5
1.20	20.052	20.170	20.05	23.65	45.54	26.59	48.99	.290	609.7	1794.0	51.78	96.17	210.3	175.2
1.40	20.052	20.170	20.05	20.98	45.54	23.61	48.99	.290	610.3	1799.1	51.77	96.16	210.5	191.9
1.60	20.052	20.170	20.05	21.52	45.54	24.45	48.99	.290	610.9	1804.3	51.77	96.15	210.7	158.8
1.80	20.052	20.170	20.05	22.23	45.54	25.17	48.99	.290	612.0	1809.9	51.77	96.14	211.1	165.0
2.00	20.052	20.170	37.78	25.43	63.26	28.36	48.99	.290	613.8	1817.2	51.76	96.13	409.6	192.1
2.20	20.052	20.170	43.07	25.49	68.55	28.42	48.99	.290	616.8	1826.6	51.75	96.11	476.1	193.6
2.40	20.052	20.170	50.83	30.10	76.29	33.03	48.99	.290	620.9	1838.9	51.73	96.09	574.1	233.2
2.60	20.052	20.170	61.04	33.42	86.50	36.35	48.99	.290	626.1	1855.1	51.71	96.06	710.0	265.9
2.80	20.052	20.170	73.72	34.00	99.16	36.93	48.99	.290	632.4	1874.3	51.68	96.03	890.5	274.0
3.00	20.052	20.170	60.00	32.43	85.42	35.36	48.99	.290	639.7	1894.6	51.65	95.99	711.4	262.3
3.20	20.052	20.170	20.05	32.43	45.46	35.36	48.99	.290	647.3	1915.0	51.61	95.96	223.3	265.0
3.40	20.052	20.170	20.05	32.41	45.45	35.34	48.99	.290	655.0	1935.3	51.58	95.93	225.9	267.7
3.60	20.052	20.170	20.05	32.41	45.43	35.34	48.99	.290	662.8	1955.6	51.55	95.89	228.6	270.5
3.80	20.052	20.170	20.05	32.41	45.42	35.34	48.99	.290	670.5	1976.0	51.52	95.86	231.3	273.4
4.00														

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE = ORBITER 040A, LOW PENMN = OXYGEN SUPPLY SYSTEM

MINIMUM REQUIRED ULLAGE PRESSURE FOR 3 ENGINE OPERATION PER MAIN FEED LINE

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
.20	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
.40	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
.60	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
.80	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
1.00	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
1.20	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
1.40	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
1.60	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
1.80	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
2.00	37.780	25.229	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
2.20	43.072	28.923	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
2.40	50.825	34.328	21.974	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
2.60	61.041	41.452	27.105	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
2.80	73.718	50.294	33.473	20.978	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
3.00	59.996	36.527	20.232	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
3.20	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
3.40	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
3.60	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
3.80	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE = ORBITER 040A, LOW PENMN = HYDROGEN SUPPLY SYSTEM

MINIMUM REQUIRED ULLAGE PRESSURE FOR 3 ENGINE OPERATION PER MAIN FEED LINE

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	20.522	20.501	20.484	20.470	20.459	20.450	20.442	20.436	20.430	20.425	20.421	20.417
.20	20.551	20.526	20.506	20.490	20.477	20.466	20.457	20.449	20.443	20.437	20.432	20.428
.40	20.723	20.676	20.638	20.608	20.584	20.563	20.546	20.532	20.520	20.509	20.500	20.492
.60	20.959	20.880	20.818	20.768	20.728	20.695	20.667	20.643	20.623	20.606	20.592	20.579
.80	21.357	21.223	21.118	21.035	20.968	20.912	20.866	20.827	20.794	20.766	20.742	20.721
1.00	22.892	22.546	22.275	22.062	21.890	21.750	21.633	21.536	21.453	21.382	21.321	21.268
1.20	23.655	23.155	22.780	22.489	22.260	22.075	21.924	21.798	21.693	21.603	21.527	21.461
1.40	20.679	20.524	20.430	20.373	20.337	20.315	20.302	20.294	20.290	20.288	20.288	20.289
1.60	21.519	21.257	21.077	20.950	20.858	20.788	20.736	20.694	20.662	20.636	20.614	20.596
1.80	22.233	21.858	21.594	21.403	21.260	21.151	21.065	20.997	20.942	20.897	20.859	20.828
2.00	25.425	24.556	23.922	23.447	23.080	22.792	22.560	22.371	22.215	22.084	21.973	21.878
2.20	25.486	24.449	23.723	23.197	22.805	22.506	22.272	22.086	21.936	21.814	21.711	21.626
2.40	30.097	28.208	26.872	25.897	25.163	24.599	24.155	23.800	23.511	23.273	23.074	22.906
2.60	33.416	30.625	28.694	27.312	26.294	25.525	24.932	24.465	24.091	23.787	23.537	23.329
2.80	33.998	30.669	28.428	26.867	25.748	24.926	24.309	23.836	23.467	23.175	22.941	22.750
3.00	32.434	29.118	26.932	25.445	24.405	23.661	23.116	22.711	22.404	22.168	21.984	21.839
3.20	32.427	29.105	26.916	25.428	24.387	23.643	23.099	22.694	22.388	22.152	21.969	21.825
3.40	32.412	29.091	26.902	25.414	24.375	23.631	23.088	22.684	22.378	22.143	21.961	21.817
3.60	32.413	29.092	26.903	25.415	24.376	23.632	23.089	22.685	22.379	22.144	21.962	21.818
3.80	32.414	29.093	26.904	25.416	24.377	23.633	23.090	22.686	22.380	22.145	21.963	21.819
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, LOW PENMN - OXYGEN SUPPLY SYSTEM

TANK BOTTOM PRESSURE VALUES FOR 3 ENGINE OPERATION PER MAIN FEED LINE

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
,00	45,549	45,549	45,549	45,549	45,549	45,549	45,549	45,549	45,549	45,549	45,549	45,549
,20	45,549	45,549	45,549	45,549	45,549	45,549	45,549	45,549	45,549	45,549	45,549	45,549
,40	45,548	45,548	45,548	45,548	45,548	45,548	45,548	45,548	45,548	45,548	45,548	45,548
,60	45,548	45,548	45,548	45,548	45,548	45,548	45,548	45,548	45,548	45,548	45,548	45,548
,80	45,547	45,547	45,547	45,547	45,547	45,547	45,547	45,547	45,547	45,547	45,547	45,547
1,00	45,546	45,546	45,546	45,546	45,546	45,546	45,546	45,546	45,546	45,546	45,546	45,546
1,20	45,545	45,545	45,545	45,545	45,545	45,545	45,545	45,545	45,545	45,545	45,545	45,545
1,40	45,543	45,543	45,543	45,543	45,543	45,543	45,543	45,543	45,543	45,543	45,543	45,543
1,60	45,542	45,542	45,542	45,542	45,542	45,542	45,542	45,542	45,542	45,542	45,542	45,542
1,80	45,540	45,540	45,540	45,540	45,540	45,540	45,540	45,540	45,540	45,540	45,540	45,540
2,00	63,264	50,713	45,536	45,536	45,536	45,536	45,536	45,536	45,536	45,536	45,536	45,536
2,20	68,549	54,397	45,529	45,529	45,529	45,529	45,529	45,529	45,529	45,529	45,529	45,529
2,40	76,294	59,796	47,442	45,521	45,521	45,521	45,521	45,521	45,521	45,521	45,521	45,521
2,60	86,498	66,910	52,563	45,510	45,510	45,510	45,510	45,510	45,510	45,510	45,510	45,510
2,80	99,162	75,738	58,917	46,422	45,496	45,496	45,496	45,496	45,496	45,496	45,496	45,496
3,00	85,425	61,956	45,661	45,481	45,481	45,481	45,481	45,481	45,481	45,481	45,481	45,481
3,20	45,465	45,465	45,465	45,465	45,465	45,465	45,465	45,465	45,465	45,465	45,465	45,465
3,40	45,449	45,449	45,449	45,449	45,449	45,449	45,449	45,449	45,449	45,449	45,449	45,449
3,60	45,432	45,432	45,432	45,432	45,432	45,432	45,432	45,432	45,432	45,432	45,432	45,432
3,80	45,416	45,416	45,416	45,416	45,416	45,416	45,416	45,416	45,416	45,416	45,416	45,416
4,00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, LOW PENMN - HYDROGEN SUPPLY SYSTEM

TANK BOTTOM PRESSURE VALUES FOR 3 ENGINE OPERATION PER MAIN FEED LINE

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	23.458	23.437	23.420	23.407	23.395	23.386	23.378	23.372	23.366	23.362	23.357	23.354
.20	23.487	23.462	23.442	23.426	23.413	23.403	23.393	23.386	23.379	23.374	23.369	23.364
.40	23.659	23.612	23.575	23.544	23.520	23.500	23.483	23.468	23.456	23.446	23.436	23.429
.60	23.895	23.816	23.754	23.705	23.664	23.631	23.603	23.580	23.560	23.543	23.528	23.515
.80	24.293	24.159	24.054	23.971	23.904	23.848	23.802	23.764	23.731	23.702	23.678	23.657
1.00	25.828	25.480	25.211	24.998	24.826	24.686	24.569	24.472	24.389	24.318	24.257	24.204
1.20	26.591	26.091	25.715	25.425	25.195	25.011	24.859	24.734	24.629	24.539	24.463	24.397
1.40	23.615	23.460	23.366	23.308	23.272	23.250	23.237	23.229	23.226	23.224	23.224	23.225
1.60	24.454	24.192	24.012	23.885	23.793	23.724	23.671	23.630	23.597	23.571	23.549	23.532
1.80	25.168	24.793	24.529	24.338	24.195	24.086	24.000	23.932	23.877	23.832	23.794	23.763
2.00	28.360	27.490	26.857	26.381	26.015	25.726	25.495	25.306	25.149	25.018	24.908	24.813
2.20	28.420	27.383	26.657	26.131	25.739	25.440	25.206	25.020	24.871	24.748	24.646	24.560
2.40	33.030	31.141	29.806	28.830	28.097	27.532	27.088	26.733	26.444	26.206	26.007	25.839
2.60	36.349	33.557	31.626	30.244	29.227	28.458	27.864	27.397	27.024	26.720	26.470	26.262
2.80	36.929	33.601	31.359	29.798	28.680	27.858	27.240	26.767	26.399	26.107	25.872	25.681
3.00	35.365	32.049	29.863	28.376	27.336	26.591	26.047	25.641	25.334	25.098	24.915	24.770
3.20	35.357	32.035	29.846	28.357	27.317	26.572	26.028	25.623	25.317	25.082	24.899	24.754
3.40	35.341	32.019	29.831	28.343	27.303	26.559	26.016	25.612	25.306	25.072	24.889	24.745
3.60	35.341	32.019	29.831	28.343	27.303	26.559	26.016	25.612	25.306	25.072	24.889	24.745
3.80	35.341	32.019	29.831	28.343	27.303	26.559	26.016	25.612	25.306	25.072	24.889	24.745
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, LOW PENMN - OXYGEN SUPPLY SYSTEM

RECOMPUTED ENGINE PRESSURES FOR 3 ENGINE OPERATION PER MAIN FEED LINE

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	94.539	94.539	94.539	94.539	94.539	94.539	94.539	94.539	94.539	94.539	94.539	94.539
.20	91.805	92.195	92.504	92.754	92.958	93.127	93.269	93.389	93.491	93.580	93.656	93.723
.40	91.802	92.192	92.502	92.752	92.957	93.126	93.266	93.388	93.491	93.579	93.656	93.722
.60	89.059	89.842	90.463	90.964	91.373	91.713	91.997	92.237	92.443	92.619	92.772	92.906
.80	58.847	63.962	68.013	71.277	73.946	76.156	78.007	79.572	80.908	82.057	83.053	83.922
1.00	95.734	95.619	95.510	95.411	95.323	95.246	95.179	95.120	95.067	95.022	94.982	94.946
1.20	95.228	95.184	95.132	95.081	95.032	94.987	94.947	94.911	94.878	94.850	94.825	94.802
1.40	94.174	94.283	94.353	94.400	94.432	94.454	94.471	94.482	94.491	94.497	94.503	94.507
1.60	83.143	84.840	86.166	87.224	88.081	88.787	89.374	89.870	90.290	90.651	90.964	91.235
1.80	55.238	61.005	65.535	69.162	72.112	74.546	76.578	78.292	79.750	81.004	82.089	83.035
2.00	28.000	28.000	32.631	40.453	46.796	52.016	56.365	60.028	63.137	65.811	68.122	70.134
2.20	28.000	28.000	29.973	38.482	45.298	50.849	55.436	59.274	62.501	65.276	67.664	69.736
2.40	28.000	28.000	28.000	35.596	43.102	49.139	54.075	58.169	61.571	64.492	66.993	69.152
2.60	28.000	28.000	28.000	31.793	40.211	46.888	52.283	56.713	60.345	63.460	66.110	68.384
2.80	28.000	28.000	28.000	28.000	36.622	44.093	50.060	54.907	58.825	62.179	65.013	67.431
3.00	28.000	28.000	28.000	39.547	48.250	54.881	60.049	64.157	67.372	70.117	72.399	74.319
3.20	31.144	49.443	61.362	69.392	74.963	78.930	81.820	83.968	85.476	86.749	87.744	88.532
3.40	36.023	53.716	65.128	72.733	77.947	81.611	84.243	86.170	87.486	88.594	89.444	90.105
3.60	36.007	53.700	65.112	72.717	77.931	81.595	84.227	86.154	87.470	88.577	89.428	90.089
3.80	35.991	53.684	65.096	72.701	77.915	81.579	84.211	86.138	87.454	88.561	89.412	90.073
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, LOW PENMN - HYDROGEN SUPPLY SYSTEM

RECOMPUTED ENGINE PRESSURES FOR 3 ENGINE OPERATION PER MAIN FEED LINE

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
.20	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
.40	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
.60	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
.80	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
1.00	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
1.20	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
1.40	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
1.60	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
1.80	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
2.00	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
2.20	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
2.40	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
2.60	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
2.80	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
3.00	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
3.20	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
3.40	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
3.60	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
3.80	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000	23.000
4.00												

Table 2-4

SOPSA OUTOUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, LOW PENMN - FEED SYSTEM WEIGHTS

PROPELLANT	MAIN FEEDLINE DIAMETER (INCHES)	ENGINE FEEDLINE WEIGHTS LINE NO 1	LINE NO 2	LINE NO3	LINE NO 4	TOTAL ENGINE FEEDLINE WEIGHT	MAIN FEEDLINE WEIGHT	ENGINE FEEDLINE INSULATION WEIGHT	MAIN FEEDLINE INSULATION WEIGHT	TOTAL FEED SYSTEM WEIGHT
OXYGEN	12,000	282,46	288,95	293,08	,00000	864,49	1331,6	15,585	72,077	2283,7
OXYGEN	13,000	282,46	288,95	293,08	,00000	864,49	1566,4	15,585	78,322	2524,8
OXYGEN	14,000	282,46	288,95	293,08	,00000	864,49	1823,6	15,585	84,631	2793,3
OXYGEN	15,000	282,46	288,95	293,08	,00000	864,49	2120,0	15,585	91,002	3091,0
OXYGEN	16,000	282,46	288,95	293,08	,00000	864,49	2445,4	15,585	97,436	3423,0
OXYGEN	17,000	282,46	288,95	293,08	,00000	864,49	2813,1	15,585	103,93	3797,1
OXYGEN	18,000	282,46	288,95	293,08	,00000	864,49	3216,6	15,585	110,49	4207,2
OXYGEN	19,000	282,46	288,95	293,08	,00000	864,49	3657,7	15,585	117,12	4654,9
OXYGEN	20,000	282,46	288,95	293,08	,00000	864,49	4137,9	15,585	123,80	5141,8
OXYGEN	21,000	282,46	288,95	293,08	,00000	864,49	4659,0	15,585	130,55	5669,7
OXYGEN	22,000	282,46	288,95	293,08	,00000	864,49	5222,7	15,585	137,36	6240,2
OXYGEN	23,000	282,46	288,95	293,08	,00000	864,49	5830,7	15,585	144,24	6855,0
HYDROGEN	12,000	291,08	252,21	331,46	,00000	874,75	711,31	,00000	,00000	1586,1
HYDROGEN	13,000	291,08	252,21	331,46	,00000	874,75	871,90	,00000	,00000	1746,7
HYDROGEN	14,000	291,08	252,21	331,46	,00000	874,75	1057,0	,00000	,00000	1931,8
HYDROGEN	15,000	291,08	252,21	331,46	,00000	874,75	1268,5	,00000	,00000	2143,2
HYDROGEN	16,000	291,08	252,21	331,46	,00000	874,75	1508,1	,00000	,00000	2382,9
HYDROGEN	17,000	291,08	252,21	331,46	,00000	874,75	1777,9	,00000	,00000	2652,6
HYDROGEN	18,000	291,08	252,21	331,46	,00000	874,75	2079,8	,00000	,00000	2954,6
HYDROGEN	19,000	291,08	252,21	331,46	,00000	874,75	2416,3	,00000	,00000	3291,1
HYDROGEN	20,000	291,08	252,21	331,46	,00000	874,75	2790,0	,00000	,00000	3664,8
HYDROGEN	21,000	291,08	252,21	331,46	,00000	874,75	3204,3	,00000	,00000	4079,0
HYDROGEN	22,000	291,08	252,21	331,46	,00000	874,75	3663,7	,00000	,00000	4538,4
HYDROGEN	23,000	291,08	252,21	331,46	,00000	874,75	4175,3	,00000	,00000	5050,0

END OF CASE 1

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

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                    SAMPLE CASE - ORBITER 040A, HIGH PENMN

          INPUT DATA FOR START TRANSIENT PROBLEM CONSIDERED IN THIS ANALYSIS,

THE NUMBER OF LINE SIZES TO BE CONSIDERED IS      15
THE PROBLEM CONSIDERS BOTH OXIDIZER AND FUEL FEED SYSTEMS
THE NUMBER OF ENGINES FOR THE VEHICLE IS      3
THE NUMBER OF ENGINES FOR EACH FEED SYSTEM IS      3
THE NOMINAL OXIDIZER FLOW RATE IS  894,00 LBS/SEC
THE NOMINAL FUEL FLOW RATE IS  149,00 LBS/SEC
THE VEHICLE LOADED WEIGHT IS  5503250,00 LBS
THE NOMINAL THRUST FOR EACH ENGINE IS 470000,00 LBS
THE BULK OXID, ENGINE INLET TEMPERATURE IS  162,90 DEG,R
THE BULK FUEL ENGINE INLET TEMPERATURE IS   37,00 DEG,R
THE COMPONENT PRESSURE TOLERANCE IS  3,00 PSI
THE OXID, HEAD HEIGHT IN THE TANK IS  51,784 FT
THE OXID, HEAD HEIGHT IN THEFEED LINE IS  99,500 FT
THE FUEL HEAD HEIGHT IN THE TANK IS  96,186 FT
THE FUEL HEAD HEIGHT IN THE FEED LINE IS  =9,500FT
THE INITIAL ULLAGE VOLUME IN THE OXIDIZER TANK IS      608,CU,FT
THE INITIAL ULLAGE VOLUME IN THE FUEL TANK IS     1784, CU,FT
THE INITIAL OXIDIZER LOADING IS  1743858, LBS
THE INITIAL FUEL LOADING IS     290643, LBS
THE EXTERNAL SURFACE AREA OF THE DROP TANK IS     13653,1 SQ, FT,
THE EXTERNAL SURFACE AREA OF THE LOX/LH2 BULKHEAD IS  1160,2 SQ, FT,
THE TOTAL SURFACE AREA IS THEREFORE     14813,4 SQ, FT,
THE OXYGEN FEEDLINE DESIGN PRESSURE IS ,00000000    PSI
THE HYDROGEN FEEDLINE DESIGN PRESSURE IS ,00000000    PSI
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Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

THE TANK GEOMETRY INPUT VALUES ARE AS FOLLOWS = ,

L1= 120,000 L2= 549,000 L3= 551,000 L4=1691,000 R1= 120,000 R2= 120,000 R3= 128,000 R4= 181,000 R5= 128,000

TABLE OF FEED LINE DATA

OXIDIZER LINES			FUEL LINES		
DIAMETER INCHES	LENGTH FEET	K-FACTOR	DIAMETER INCHES	LENGTH FEET	K-FACTOR
12,00	6,80	,4143	12,00	7,14	,4073
12,00	12,43	,5499	12,00	11,85	,6388
12,00	16,31	,6353	12,00	19,99	,8469
12,00	143,00	3,0925	12,00	39,00	1,4212
13,00	143,00	2,9399	13,00	39,00	1,3822
14,00	143,00	2,8095	14,00	39,00	1,3493
15,00	143,00	2,6970	15,00	39,00	1,3214
16,00	143,00	2,5991	16,00	39,00	1,2975
17,00	143,00	2,5133	17,00	39,00	1,2769
18,00	143,00	2,4375	18,00	39,00	1,2591
19,00	143,00	2,3702	19,00	39,00	1,2436
20,00	143,00	2,3601	20,00	39,00	1,2302
21,00	143,00	2,3063	21,00	39,00	1,2185
22,00	143,00	2,2579	22,00	39,00	1,2083
23,00	143,00	2,2142	23,00	39,00	1,1994

COMPONENT DESCRIPTORS FOR MAIN OXYGEN FEEDLINE

COMPONENT	TYPE	MATL	INSUL	SPEC1	SPEC2	SPEC3
1	1	0	0	,0000	,0000	,0000
2	3	2	5	5,000	20,00	,7500
3	20	0	0	,0000	,0000	,0000
4	3	2	5	9,160	13,33	,7500
5	20	0	0	,0000	,0000	,0000
6	3	2	5	4,160	8,330	,7500
7	2	2	5	7,000	,0000	,7500
8	22	0	0	,0000	,0000	,0000
9	2	2	5	72,00	,0000	,7500
10	22	0	0	,0000	,0000	,0000
11	2	2	5	4,000	,0000	,7500
12	3	2	5	4,100	1,750	,7500
13	3	2	5	1,380	1,750	,7500
14	2	2	5	4,000	,0000	,7500
15	15	0	0	,0000	,0000	,0000
16	20	0	0	,0000	,0000	,0000
17	3	2	5	1,000	1,270	,7500
18	20	0	0	,0000	,0000	,0000
19	2	2	5	1,500	,0000	,7500
20	16	0	0	,0000	,0000	,0000
21	3	2	5	4,000	7,650	,7500
22	15	0	0	,0000	,0000	,0000
23	20	0	0	,0000	,0000	,0000

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

24	2	2	5	7,000	,0000	,7500
25	20	0	0	,0000	,0000	,0000
26	8	2	5	1,000	1,500	,7500

COMPONENT DESCRIPTORS FOR ENGINE OXYGEN FEEDLINE NUMBER 1

COMPONENT	TYPE	MAT.	INSUL	SPEC1	SPEC2	SPEC3
1	20	0	0	,0000	,0000	,0000
2	3	2	5	3,800	1,500	,7500
3	20	0	0	,0000	,0000	,0000
4	15	0	0	,0000	,0000	,0000

COMPONENT DESCRIPTORS FOR ENGINE OXYGEN FEEDLINE NUMBER 2

COMPONENT	TYPE	MAT.	INSUL	SPEC1	SPEC2	SPEC3
1	20	0	0	,0000	,0000	,0000
2	3	2	5	5,500	1,750	,7500
3	3	2	5	3,930	2,500	,7500
4	20	0	0	,0000	,0000	,0000
5	15	0	0	,0000	,0000	,0000

COMPONENT DESCRIPTORS FOR ENGINE OXYGEN FEEDLINE NUMBER 3

COMPONENT	TYPE	MAT.	INSUL	SPEC1	SPEC2	SPEC3
1	20	0	0	,0000	,0000	,0000
2	3	2	5	4,710	2,000	,7500
3	3	2	5	1,500	2,860	,7500
4	2	2	5	3,000	,0000	,7500
5	3	2	5	3,800	1,500	,7500
6	20	0	0	,0000	,0000	,0000
7	15	0	0	,0000	,0000	,0000

COMPONENT DESCRIPTORS FOR MAIN HYDROGEN FEEDLINE

COMPONENT	TYPE	MAT.	INSUL	SPEC1	SPEC2	SPEC3
1	1	0	0	,0000	,0000	,0000
2	2	7	0	1,000	,0000	,0000
3	20	0	0	,0000	,0000	,0000
4	3	7	0	9,440	12,00	,0000
5	20	0	0	,0000	,0000	,0000
6	3	7	0	9,440	12,00	,0000
7	20	0	0	,0000	,0000	,0000
8	15	0	0	,0000	,0000	,0000
9	3	7	0	2,750	1,750	,0000
10	16	0	0	,0000	,0000	,0000
11	3	7	0	,9200	1,750	,0000
12	15	0	0	,0000	,0000	,0000
13	20	0	0	,0000	,0000	,0000
14	2	7	0	3,750	,0000	,0000

COMPONENT DESCRIPTORS FOR ENGINE HYDROGEN FEEDLINE NUMBER 1

COMPONENT	TYPE	MAT.	INSUL	SPEC1	SPEC2	SPEC3

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

1	8	7	0	1,000	1,350	,0000
2	20	0	0	,0000	,0000	,0000
3	3	7	0	3,140	1,500	,0000
4	20	0	0	,0000	,0000	,0000
5	15	0	0	,0000	,0000	,0000

COMPONENT DESCRIPTORS FOR ENGINE HYDROGEN FEEDLINE NUMBER 2

COMPONENT	TYPE	MATL	INSUL	SPEC1	SPEC2	SPEC3
1	3	7	0	2,350	1,500	,0000
2	4	7	0	7,500	1,500	,0000
3	20	0	0	,0000	,0000	,0000
4	15	0	0	,0000	,0000	,0000

COMPONENT DESCRIPTORS FOR ENGINE HYDROGEN FEEDLINE NUMBER 3

COMPONENT	TYPE	MATL	INSUL	SPEC1	SPEC2	SPEC3
1	20	0	0	,0000	,0000	,0000
2	3	7	0	2,350	1,500	,0000
3	3	7	0	9,150	1,750	,0000
4	3	7	0	5,490	1,750	,0000
5	20	0	0	,0000	,0000	,0000
6	15	0	0	,0000	,0000	,0000

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

THE TIME DEPENDENT PERFORMANCE CHARACTERISTIC INPUT VALUES ARE AS FOLLOWS . .

TIME	NPSPO	NPSPH	WDTFRO	WDTFRH	FIFRAC	PENMNO	PENMNH	PPDGOT	PPDGHT	TDGOT	TDGHT
,00	8,00	2,00	,000	,000	,000	60,00	30,00	,00	,00	190,00	60,00
,20	8,00	2,00	,000	,006	,000	60,00	30,00	,00	,00	190,00	60,00
,40	8,00	2,00	,005	,013	,005	60,00	30,00	,00	,00	190,00	60,00
,60	8,00	2,00	,010	,026	,010	60,00	30,00	,00	,00	190,00	60,00
,80	8,00	2,00	,020	,047	,020	60,00	30,00	,00	,00	190,00	60,00
1,00	8,00	2,00	,085	,081	,085	60,00	30,00	,00	,00	190,00	60,00
1,20	8,00	2,00	,082	,165	,082	60,00	30,00	,00	,00	190,00	60,00
1,40	8,00	2,00	,080	,263	,080	60,00	30,00	,00	,00	190,00	60,00
1,60	8,00	2,00	,080	,246	,080	60,00	30,00	,00	,00	190,00	60,00
1,80	8,00	2,00	,100	,260	,100	60,00	30,00	,00	,00	190,00	60,00
2,00	8,00	2,00	,170	,294	,170	60,00	30,00	,00	,00	190,00	60,00
2,20	8,00	2,00	,318	,420	,318	60,00	30,00	,00	,00	190,00	60,00
2,40	8,00	2,00	,466	,510	,466	60,00	30,00	,00	,00	190,00	60,00
2,60	8,00	2,00	,614	,700	,614	60,00	30,00	,00	,00	190,00	60,00
2,80	8,00	2,00	,762	,893	,762	60,00	30,00	,00	,00	190,00	60,00
3,00	8,00	2,00	,910	,996	,910	60,00	30,00	,00	,00	190,00	60,00
3,20	8,00	2,00	1,010	,999	1,010	60,00	30,00	,00	,00	190,00	60,00
3,40	8,00	2,00	1,020	1,000	1,020	60,00	30,00	,00	,00	190,00	60,00
3,60	8,00	2,00	1,020	1,000	1,020	60,00	30,00	,00	,00	190,00	60,00
3,80	8,00	2,00	1,020	1,000	1,020	60,00	30,00	,00	,00	190,00	60,00
4,00	8,00	2,00	1,020	1,000	1,020	60,00	30,00	,00	,00	190,00	60,00

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE = ORBITER 040A, HIGH PENMN

TRANS. TIME	WDDOT OXID.	WDDOT FUEL	VEHICLE WEIGHT	T/W RATIO	DELPHD OXID.	DELPHD FUEL	PROP-O INCR	PROP-F INCR	PROP-TOT CUM	PENO OXID	PENO FUEL
.00	.000	4.470	5503249.75	1.000	74.49	2.65	.000	.268	.268	60.00	30.00
.20	22.350	5.215	5503247.56	1.000	74.49	2.65	1.341	.849	2.458	60.00	30.00
.40	22.350	9.685	5503241.81	1.000	74.49	2.65	4.023	1.743	8.225	60.00	30.00
.60	44.700	15.645	5503230.56	1.000	74.49	2.65	8.046	3.263	19.534	60.00	30.00
.80	290.550	25.330	5503196.69	1.000	74.49	2.65	28.161	5.722	53.416	60.00	30.00
1.00	513.410	62.580	5503140.94	1.000	74.48	2.65	44.789	10.996	109.202	60.00	30.00
1.20	468.940	73.010	5503078.37	1.000	74.48	2.65	43.448	19.132	171.782	60.00	30.00
1.40	.000	412.665	5503012.75	1.000	74.48	2.65	42.912	22.752	237.446	60.00	30.00
1.60	89.400	10.430	5502941.87	1.000	74.48	2.65	48.276	22.618	308.341	60.00	30.00
1.80	312.900	25.330	5502844.75	1.000	74.48	2.64	72.414	24.764	405.518	60.00	30.00
2.00	661.560	93.870	5502682.00	1.000	74.47	2.64	130.842	31.916	568.316	60.00	30.00
2.20	661.560	67.050	5502430.19	1.000	74.47	2.64	210.269	41.571	820.156	60.00	30.00
2.40	661.560	141.550	5502086.50	1.000	74.46	2.64	289.656	54.087	1163.899	60.00	30.00
2.60	661.560	143.785	5501646.25	1.000	74.45	2.64	369.043	71.207	1604.149	60.00	30.00
2.80	661.560	76.735	5501113.44	1.000	74.43	2.64	448.430	84.438	2137.018	60.00	30.00
3.00	447.000	2.235	5500509.37	1.000	74.42	2.64	514.944	89.176	2741.138	60.00	30.00
3.20	44.700	.745	5499875.62	1.000	74.40	2.64	544.446	89.355	3374.939	60.00	30.00
3.40	.000	.000	5499239.12	1.000	74.39	2.64	547.128	89.400	4011.467	60.00	30.00
3.60	.000	.000	5498602.62	1.000	74.37	2.64	547.128	89.400	4647.995	60.00	30.00
3.80	.000	.000	5497966.12	1.000	74.35	2.64	547.128	89.400	5284.523	60.00	30.00
4.00											

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE = ORBITER 040A, HIGH PENMN = OXYGEN SUPPLY SYSTEM

DELTA-P TO SUPPLY ACCELERATION HEAD

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
,00	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000
,20	2,635	2,245	1,936	1,686	1,482	1,313	1,171	1,051	,949	,860	,784	,717
,40	2,635	2,245	1,936	1,686	1,482	1,313	1,171	1,051	,949	,860	,784	,717
,60	5,270	4,491	3,872	3,373	2,965	2,626	2,342	2,102	1,897	1,721	1,568	1,435
,80	34,257	29,189	25,168	21,924	19,269	17,069	15,225	13,665	12,332	11,186	10,192	9,325
1,00	-1,581	-1,347	-1,162	-1,012	-,889	-,788	-,703	-,631	-,569	-,516	-,470	-,430
1,20	-1,054	-,898	-,774	-,675	-,593	-,525	-,468	-,420	-,379	-,344	-,314	-,287
1,40	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000
1,60	10,541	8,981	7,744	6,746	5,929	5,252	4,685	4,205	3,795	3,442	3,136	2,869
1,80	36,892	31,435	27,104	23,611	20,752	18,382	16,396	14,716	13,281	12,046	10,976	10,042
2,00	78,000	66,462	57,306	49,920	43,875	38,865	34,667	31,114	28,080	25,469	23,207	21,233
2,20	78,000	66,462	57,306	49,920	43,875	38,865	34,667	31,114	28,080	25,469	23,207	21,233
2,40	78,000	66,462	57,306	49,920	43,875	38,865	34,667	31,114	28,080	25,469	23,207	21,233
2,60	78,000	66,462	57,306	49,920	43,875	38,865	34,667	31,114	28,080	25,469	23,207	21,233
2,80	78,000	66,462	57,306	49,920	43,875	38,865	34,667	31,114	28,080	25,469	23,207	21,233
3,00	52,703	44,907	38,720	33,730	29,645	26,260	23,424	21,023	18,973	17,209	15,680	14,346
3,20	5,270	4,491	3,872	3,373	2,965	2,626	2,342	2,102	1,897	1,721	1,568	1,435
3,40	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000
3,60	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000
3,80	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000	,000
4,00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, HIGH PENMN - HYDROGEN SUPPLY SYSTEM

DELTAP TO SUPPLY ACCELERATION HEAD

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	.144	.122	.106	.092	.081	.072	.064	.057	.052	.047	.043	.039
.20	.168	.143	.123	.107	.094	.084	.075	.067	.060	.055	.050	.046
.40	.311	.265	.229	.199	.175	.155	.138	.124	.112	.102	.093	.085
.60	.503	.429	.370	.322	.283	.251	.224	.201	.181	.164	.150	.137
.80	.814	.694	.598	.521	.458	.406	.362	.325	.293	.266	.242	.222
1.00	2.012	1.715	1.478	1.288	1.132	1.003	.894	.803	.724	.657	.599	.548
1.20	2.348	2.000	1.725	1.503	1.321	1.170	1.043	.936	.845	.767	.698	.639
1.40	-.407	-.347	-.299	-.261	-.229	-.203	-.181	-.162	-.147	-.133	-.121	-.111
1.60	.335	.286	.246	.215	.189	.167	.149	.134	.121	.110	.100	.091
1.80	.814	.694	.598	.521	.458	.406	.362	.325	.293	.266	.242	.222
2.00	3.018	2.572	2.218	1.932	1.698	1.504	1.342	1.204	1.087	.986	.898	.822
2.20	2.156	1.837	1.584	1.380	1.213	1.074	.958	.860	.776	.704	.641	.587
2.40	4.552	3.878	3.344	2.913	2.560	2.268	2.023	1.816	1.639	1.486	1.354	1.239
2.60	4.623	3.940	3.397	2.959	2.601	2.304	2.055	1.844	1.664	1.510	1.376	1.259
2.80	2.467	2.102	1.813	1.579	1.388	1.229	1.097	.984	.888	.806	.734	.672
3.00	.072	.061	.053	.046	.040	.036	.032	.029	.026	.023	.021	.020
3.20	.024	.020	.018	.015	.013	.012	.011	.010	.009	.008	.007	.007
3.40	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
3.60	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
3.80	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE = ORBITER 040A, HIGH PENMN = OXYGEN SUPPLY SYSTEM

DELTA-P DUE TO LINE FRICTION AND CONFIGURATION LOSSES

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
.20	.3431-03	.2368-03	.1682-03	.1226-03	.9124-04	.6923-04	.5342-04	.4184-04	.3393-04	.2728-04	.2217-04	.1820-04
.40	.3088-02	.2131-02	.1514-02	.1103-02	.8211-03	.6230-03	.4807-03	.3766-03	.3054-03	.2455-03	.1996-03	.1638-03
.60	.1235-01	.8525-02	.6057-02	.4412-02	.3285-02	.2492-02	.1923-02	.1506-02	.1222-02	.9821-03	.7983-03	.6553-03
.80	.1513+00	.1044+00	.7420-01	.5405-01	.4024-01	.3053-01	.2356-01	.1845-01	.1497-01	.1203-01	.9779-02	.8027-02
1.00	.3827+00	.2642+00	.1877+00	.1367+00	.1018+00	.7723-01	.5959-01	.4667-01	.3786-01	.3043-01	.2474-01	.2031-01
1.20	.3602+00	.2486+00	.1766+00	.1287+00	.9578-01	.7267-01	.5607-01	.4392-01	.3562-01	.2864-01	.2328-01	.1911-01
1.40	.3513+00	.2425+00	.1723+00	.1255+00	.9343-01	.7089-01	.5470-01	.4284-01	.3475-01	.2794-01	.2271-01	.1864-01
1.60	.4446+00	.3069+00	.2180+00	.1588+00	.1182+00	.8972-01	.6923-01	.5422-01	.4398-01	.3536-01	.2874-01	.2359-01
1.80	.1000+01	.6905+00	.4906+00	.3574+00	.2660+00	.2019+00	.1558+00	.1220+00	.9895-01	.7955-01	.6466-01	.5308-01
2.00	.3268+01	.2256+01	.1603+01	.1167+01	.8691+00	.6594+00	.5088+00	.3986+00	.3233+00	.2599+00	.2112+00	.1734+00
2.20	.8435+01	.5822+01	.4137+01	.3013+01	.2243+01	.1702+01	.1313+01	.1029+01	.8343+00	.6707+00	.5452+00	.4475+00
2.40	.1601+02	.1105+02	.7850+01	.5718+01	.4257+01	.3230+01	.2492+01	.1952+01	.1583+01	.1273+01	.1035+01	.8493+00
2.60	.2598+02	.1793+02	.1274+02	.9282+01	.6910+01	.5243+01	.4045+01	.3169+01	.2570+01	.2066+01	.1679+01	.1379+01
2.80	.3837+02	.2648+02	.1881+02	.1371+02	.1020+02	.7741+01	.5973+01	.4679+01	.3795+01	.3051+01	.2480+01	.2035+01
3.00	.5059+02	.3492+02	.2481+02	.1807+02	.1345+02	.1021+02	.7877+01	.6170+01	.5004+01	.4023+01	.3270+01	.2684+01
3.20	.5655+02	.3903+02	.2773+02	.2020+02	.1504+02	.1141+02	.8805+01	.6897+01	.5594+01	.4497+01	.3655+01	.3000+01
3.40	.5711+02	.3942+02	.2801+02	.2040+02	.1519+02	.1152+02	.8892+01	.6965+01	.5649+01	.4541+01	.3691+01	.3030+01
3.60	.5711+02	.3942+02	.2801+02	.2040+02	.1519+02	.1152+02	.8892+01	.6965+01	.5649+01	.4541+01	.3691+01	.3030+01
3.80	.5711+02	.3942+02	.2801+02	.2040+02	.1519+02	.1152+02	.8892+01	.6965+01	.5649+01	.4541+01	.3691+01	.3030+01
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, HIGH PENMN - HYDROGEN SUPPLY SYSTEM

DELTA-P DUE TO LINE FRICTION AND CONFIGURATION LOSSES

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	.1017-03	.7183-04	.5213-04	.3874-04	.2938-04	.2269-04	.1780-04	.1416-04	.1141-04	.9299-05	.7655-05	.6361-05
.20	.1020-02	.7202-03	.5227-03	.3885-03	.2946-03	.2275-03	.1785-03	.1420-03	.1144-03	.9325-04	.7677-04	.6379-04
.40	.4298-02	.3035-02	.2202-02	.1637-02	.1241-02	.9586-03	.7521-03	.5984-03	.4821-03	.3929-03	.3234-03	.2688-03
.60	.1506-01	.1063-01	.7717-02	.5734-02	.4349-02	.3359-02	.2635-02	.2096-02	.1689-02	.1376-02	.1133-02	.9416-03
.80	.4629-01	.3269-01	.2372-01	.1763-01	.1337-01	.1033-01	.8101-02	.6446-02	.5193-02	.4232-02	.3484-02	.2895-02
1.00	.1710+00	.1207+00	.8763-01	.6512-01	.4939-01	.3814-01	.2992-01	.2381-01	.1918-01	.1563-01	.1287-01	.1069-01
1.20	.5176+00	.3655+00	.2653+00	.1971+00	.1495+00	.1155+00	.9058-01	.7207-01	.5806-01	.4732-01	.3895-01	.3237-01
1.40	.7321+00	.5169+00	.3752+00	.2788+00	.2115+00	.1633+00	.1281+00	.1019+00	.8212-01	.6692-01	.5509-01	.4578-01
1.60	.7235+00	.5108+00	.3707+00	.2755+00	.2090+00	.1614+00	.1266+00	.1007+00	.8116-01	.6613-01	.5445-01	.4524-01
1.80	.8672+00	.6123+00	.4444+00	.3303+00	.2505+00	.1934+00	.1518+00	.1207+00	.9728-01	.7928-01	.6526-01	.5423-01
2.00	.1440+01	.1017+01	.7382+00	.5486+00	.4161+00	.3213+00	.2521+00	.2006+00	.1616+00	.1317+00	.1084+00	.9008-01
2.20	.2444+01	.1726+01	.1252+01	.9307+00	.7059+00	.5451+00	.4277+00	.3403+00	.2742+00	.2234+00	.1839+00	.1528+00
2.40	.4137+01	.2921+01	.2120+01	.1575+01	.1195+01	.9228+00	.7239+00	.5760+00	.4641+00	.3782+00	.3113+00	.2587+00
2.60	.7170+01	.5063+01	.3675+01	.2731+01	.2071+01	.1599+01	.1255+01	.9983+00	.8044+00	.6555+00	.5396+00	.4484+00
2.80	.1008+02	.7119+01	.5167+01	.3840+01	.2912+01	.2249+01	.1764+01	.1404+01	.1131+01	.9217+00	.7588+00	.6305+00
3.00	.1125+02	.7941+01	.5763+01	.4283+01	.3248+01	.2508+01	.1968+01	.1566+01	.1262+01	.1028+01	.8463+00	.7033+00
3.20	.1129+02	.7973+01	.5786+01	.4300+01	.3261+01	.2519+01	.1976+01	.1572+01	.1267+01	.1032+01	.8497+00	.7061+00
3.40	.1130+02	.7981+01	.5792+01	.4304+01	.3265+01	.2521+01	.1978+01	.1574+01	.1268+01	.1033+01	.8506+00	.7068+00
3.60	.1130+02	.7981+01	.5792+01	.4304+01	.3265+01	.2521+01	.1978+01	.1574+01	.1268+01	.1033+01	.8506+00	.7068+00
3.80	.1130+02	.7981+01	.5792+01	.4304+01	.3265+01	.2521+01	.1978+01	.1574+01	.1268+01	.1033+01	.8506+00	.7068+00
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, HIGH PENMN -OXYGEN ENGINE FEEDLINE SYSTEM

	DELTA-P TO SUPPLY ACCELERATION HEAD				DELTA-P DUE TO LINE FRICTION AND CONFIGURATION LOSSES			
DELTA TIME	ENGINE LINE NO 1	ENGINE LINE NO 2	ENGINE LINE NO 3	ENGINE LINE NO 4	ENGINE LINE NO 1	ENGINE LINE NO 2	ENGINE LINE NO 3	ENGINE LINE NO 4
,00	,00000000	,00000000	,00000000	,00000000	,00000000	,00000000	,00000000	,00000000
,20	,41769110-01	,76351536-01	,98341784-01	,00000000	,5106539E-05	,67791624-05	,78310665-05	,00000000
,40	,41769109-01	,76351536-01	,98341782-01	,00000000	,45958857-04	,61012462-04	,70479599-04	,00000000
,60	,83538221-01	,15270308	,19668357	,00000000	,18383543-03	,24404985-03	,28191840-03	,00000000
,80	,54299843	,99256998	1,2784432	,00000000	,22519839-02	,29896106-02	,34535003-02	,00000000
1,00	-,25061462-01	-,45810915-01	-,59005060-01	,00000000	,56966513-02	,75625624-02	,87360246-02	,00000000
1,20	-,16707646-01	-,30540619-01	-,39336719-01	,00000000	,53606410-02	,71164935-02	,82207404-02	,00000000
1,40	,00000000	,00000000	,00000000	,00000000	,52290966-02	,69418623-02	,80190120-02	,00000000
1,60	,16707643	,30540613	,39336711	,00000000	,66180752-02	,87857944-02	,10149062-01	,00000000
1,80	,58476748	1,0689214	1,3767848	,00000000	,14890669-01	,19768038-01	,22835390-01	,00000000
2,00	1,2363657	2,2600056	2,9109170	,00000000	,48643671-01	,64576673-01	,74596860-01	,00000000
2,20	1,2363655	2,2600053	2,9109165	,00000000	,12555061	,16667411	,19253648	,00000000
2,40	1,2363657	2,2600056	2,9109170	,00000000	,23825071	,31628860	,36536624	,00000000
2,60	1,2363655	2,2600053	2,9109165	,00000000	,38674399	,51342013	,59308614	,00000000
2,80	1,2363657	2,2600055	2,9109168	,00000000	,57103042	,75806872	,87569617	,00000000
3,00	,83538232	1,5270310	1,9668359	,00000000	,75298991	,99962818	1,1547378	,00000000
3,20	,83538133-01	,15270291	,19668336	,00000000	,84174157	1,1174500	1,2908417	,00000000
3,40	,00000000	,00000000	,00000000	,00000000	,85005499	1,1284865	1,3035906	,00000000
3,60	,00000000	,00000000	,00000000	,00000000	,85005499	1,1284865	1,3035906	,00000000
3,80	,00000000	,00000000	,00000000	,00000000	,85005499	1,1284865	1,3035906	,00000000
4,00								

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, HIGH PENMN -HYDROGEN ENGINE FEEDLINE SYSTEM

	DELTA-P TO SUPPLY ACCELERATION HEAD				DELTA-P DUE TO LINE FRICTION AND CONFIGURATION LOSSES			
DELTA TIME	ENGINE LINE NO 1	ENGINE LINE NO 2	ENGINE LINE NO 3	ENGINE LINE NO 4	ENGINE LINE NO 1	ENGINE LINE NO 2	ENGINE LINE NO 3	ENGINE LINE NO 4
,00	,87715138-02	,14557779-01	,24557809-01	,00000000	,32394354-05	,50801058-05	,67352826-05	,00000000
,20	,10233433-01	,16984076-01	,28650777-01	,00000000	,32484338-04	,50942172-04	,67539917-04	,00000000
,40	,19004946-01	,31541854-01	,53208584-01	,00000000	,13686614-03	,21463447-03	,28456569-03	,00000000
,60	,30700298-01	,50952227-01	,85952330-01	,00000000	,47952643-03	,75199678-03	,99700893-03	,00000000
,80	,49705245-01	,82494083-01	,13916092	,00000000	,14743030-02	,23120126-02	,30653019-02	,00000000
1,00	,12280119	,20380890	,34380931	,00000000	,54454909-02	,85396580-02	,11322010-01	,00000000
1,20	,14326806	,23777706	,40111087	,00000000	,16483687-01	,25849836-01	,34272112-01	,00000000
1,40	-,24852625-01	-,41247046-01	-,69580465-01	,00000000	,23313226-01	,36559969-01	,48471770-01	,00000000
1,60	,20466868-01	,33968156-01	,57301561-01	,00000000	,23039224-01	,36130277-01	,47902078-01	,00000000
1,80	,49705238-01	,82494070-01	,13916090	,00000000	,27617627-01	,43310160-01	,57421277-01	,00000000
2,00	,18420180	,30571339	,51571401	,00000000	,45873645-01	,71939379-01	,95378337-01	,00000000
2,20	,13157269	,21836666	,36836708	,00000000	,77827437-01	,12204954	,16181517	,00000000
2,40	,27776463	,46099638	,77766400	,00000000	,13174604	,20660508	,27392020	,00000000
2,60	,28215033	,46827518	,78994275	,00000000	,22834861	,35809793	,47477176	,00000000
2,80	,15057766	,24990856	,42157574	,00000000	,32109293	,50354023	,66760140	,00000000
3,00	,43857551-02	,72788867-02	,12278899-01	,00000000	,35813983	,56163745	,74462758	,00000000
3,20	,14619218-02	,24263012-02	,40929760-02	,00000000	,35957742	,56389189	,74761655	,00000000
3,40	,00000000	,00000000	,00000000	,00000000	,35993727	,56445621	,74836475	,00000000
3,60	,00000000	,00000000	,00000000	,00000000	,35993727	,56445621	,74836475	,00000000
3,80	,00000000	,00000000	,00000000	,00000000	,35993727	,56445621	,74836475	,00000000
4,00								

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, HIGH PENMN - OXYGEN SUPPLY SYSTEM

ULLAGE PRESSURE REQUIRED FOR 3 ENGINE OPERATION

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	-11.486	-11.486	-11.486	-11.486	-11.486	-11.486	-11.486	-11.486	-11.486	-11.486	-11.486	-11.486
.20	-8.753	-9.142	-9.452	-9.701	-9.906	-10.075	-10.217	-10.337	-10.439	-10.528	-10.604	-10.671
.40	-8.750	-9.140	-9.450	-9.700	-9.905	-10.074	-10.216	-10.336	-10.439	-10.527	-10.604	-10.670
.60	-6.006	-6.790	-7.411	-7.912	-8.321	-8.661	-8.945	-9.185	-9.391	-9.567	-9.720	-9.854
.80	24.205	19.090	15.039	11.775	9.106	6.896	5.046	3.480	2.144	.995	-.001	-.870
1.00	-12.682	-12.567	-12.458	-12.359	-12.271	-12.194	-12.127	-12.068	-12.015	-11.970	-11.929	-11.894
1.20	-12.176	-12.132	-12.080	-12.028	-11.980	-11.935	-11.895	-11.859	-11.826	-11.798	-11.773	-11.750
1.40	-11.122	-11.231	-11.301	-11.348	-11.380	-11.402	-11.418	-11.430	-11.438	-11.445	-11.450	-11.455
1.60	-.091	-1.788	-3.114	-4.171	-5.029	-5.734	-6.322	-6.817	-7.238	-7.599	-7.911	-8.183
1.80	27.815	22.047	17.517	13.890	10.940	8.506	6.474	4.760	3.302	2.048	.963	.018
2.00	72.780	60.229	50.421	42.600	36.256	31.037	26.688	23.024	19.915	17.241	14.930	12.918
2.20	78.072	63.920	53.079	44.570	37.755	32.203	27.616	23.779	20.551	17.776	15.388	13.316
2.40	85.825	69.328	56.974	47.456	39.950	33.913	28.977	24.883	21.481	18.560	16.059	13.900
2.60	96.041	76.452	62.105	51.259	42.842	36.165	30.799	26.339	22.707	19.592	16.943	14.668
2.80	108.718	85.294	68.473	55.978	46.430	38.959	32.993	28.145	24.227	20.873	18.039	15.621
3.00	94.996	71.527	55.232	43.505	34.802	28.171	23.003	18.895	15.680	12.935	10.653	8.733
3.20	51.909	33.609	21.690	13.660	8.089	4.122	1.232	-.916	-2.424	-3.697	-4.692	-5.480
3.40	47.029	29.336	17.924	10.319	5.105	1.441	-1.191	-3.118	-4.434	-5.541	-6.392	-7.053
3.60	47.045	29.352	17.940	10.335	5.121	1.457	-1.175	-3.102	-4.418	-5.525	-6.376	-7.037
3.80	47.061	29.368	17.956	10.351	5.137	1.473	-1.159	-3.086	-4.402	-5.509	-6.360	-7.021
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, HIGH PENMN - HYDROGEN SUPPLY SYSTEM

ULLAGE PRESSURE REQUIRED FOR 3 ENGINE OPERATION

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	30.522	30.501	30.484	30.470	30.459	30.450	30.442	30.436	30.430	30.425	30.421	30.417
.20	30.551	30.526	30.506	30.490	30.477	30.466	30.457	30.449	30.443	30.437	30.432	30.428
.40	30.723	30.676	30.638	30.608	30.584	30.563	30.546	30.532	30.520	30.509	30.500	30.492
.60	30.959	30.880	30.818	30.768	30.728	30.695	30.667	30.643	30.623	30.606	30.592	30.579
.80	31.357	31.223	31.118	31.035	30.968	30.912	30.866	30.827	30.794	30.766	30.742	30.721
1.00	32.892	32.544	32.275	32.062	31.890	31.750	31.633	31.536	31.453	31.382	31.321	31.268
1.20	33.655	33.155	32.780	32.489	32.260	32.075	31.924	31.798	31.693	31.603	31.527	31.461
1.40	30.679	30.524	30.430	30.373	30.337	30.315	30.302	30.294	30.290	30.288	30.288	30.289
1.60	31.519	31.257	31.077	30.950	30.858	30.788	30.736	30.694	30.662	30.636	30.614	30.596
1.80	32.233	31.858	31.594	31.403	31.260	31.151	31.065	30.997	30.942	30.897	30.859	30.828
2.00	35.425	34.556	33.922	33.447	33.080	32.792	32.560	32.371	32.215	32.084	31.973	31.878
2.20	35.486	34.449	33.723	33.197	32.805	32.506	32.272	32.086	31.936	31.814	31.711	31.626
2.40	40.097	38.208	36.872	35.897	35.163	34.599	34.155	33.800	33.511	33.273	33.074	32.906
2.60	43.416	40.625	38.694	37.312	36.294	35.525	34.932	34.465	34.091	33.787	33.537	33.329
2.80	43.998	40.669	38.428	36.867	35.748	34.926	34.309	33.836	33.467	33.175	32.941	32.750
3.00	42.434	39.118	36.932	35.445	34.405	33.661	33.116	32.711	32.404	32.168	31.984	31.839
3.20	42.427	39.105	36.916	35.428	34.387	33.643	33.099	32.694	32.388	32.152	31.969	31.825
3.40	42.412	39.091	36.902	35.414	34.375	33.631	33.088	32.684	32.378	32.143	31.961	31.817
3.60	42.413	39.092	36.903	35.415	34.376	33.632	33.089	32.685	32.379	32.144	31.962	31.818
3.80	42.414	39.093	36.904	35.416	34.377	33.633	33.090	32.686	32.380	32.145	31.963	31.819
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE = ORBITER 040A, HIGH PENMN

PRESSURE AND VOLUME VALUES FOR FLUID VAPOR, MIN. ULLAGE, TANK BOTTOM, LINE HEAD, ULLAGE VOLUME, TANK HEAD HEIGHT AND ULLAGE WEIGHT

TRANS. TIME SEC	ULLVAP OXID. PSIA	ULLVAP FUEL PSIA	MINULL OXID. PSIA	MINULL FUEL PSIA	TNKBOT OXID. PSIA	TNKBOT FUEL PSIA	LINHED OXID. PSIA	LINHED FUEL PSIA	ULLVOL OXID. CU.FT.	ULLVOL FUEL CU.FT.	TNKHED OXID. FT.	TNKHED FUEL FT.	ULLWGT OXID. LBS	ULLWGT FUEL LBS
.00														
	20.052	20.170	20.05	30.52	45.55	33.46	48.99	.290	607.8	1784.5	51.78	96.19	209.6	230.1
.20														
	20.052	20.170	20.05	30.55	45.55	33.49	48.99	.290	607.8	1784.7	51.78	96.19	209.6	230.4
.40														
	20.052	20.170	20.05	30.72	45.55	33.66	48.99	.290	607.9	1785.1	51.78	96.18	209.7	232.0
.60														
	20.052	20.170	20.05	30.96	45.55	33.90	48.99	.290	608.0	1785.8	51.78	96.18	209.7	234.1
.80														
	20.052	20.170	24.20	31.36	49.70	34.29	48.99	.290	608.4	1787.1	51.78	96.18	255.1	237.8
1.00														
	20.052	20.170	20.05	32.89	45.55	35.83	48.99	.290	609.0	1789.6	51.78	96.18	210.1	251.8
1.20														
	20.052	20.170	20.05	33.65	45.54	36.59	48.99	.290	609.7	1794.0	51.78	96.17	210.3	259.2
1.40														
	20.052	20.170	20.05	30.68	45.54	33.61	48.99	.290	610.3	1799.1	51.77	96.16	210.5	233.4
1.60														
	20.052	20.170	20.05	31.52	45.54	34.45	48.99	.290	610.9	1804.3	51.77	96.15	210.7	241.6
1.80														
	20.052	20.170	27.81	32.23	53.30	35.17	48.99	.290	612.0	1809.9	51.77	96.14	296.7	248.8
2.00														
	20.052	20.170	72.78	35.43	98.26	38.36	48.99	.290	613.8	1817.2	51.76	96.13	851.9	278.6
2.20														
	20.052	20.170	78.07	35.49	103.55	38.42	48.99	.290	616.8	1826.6	51.75	96.11	929.2	280.6
2.40														
	20.052	20.170	85.83	40.10	111.29	43.03	48.99	.290	620.9	1838.9	51.73	96.09	1047.8	324.6
2.60														
	20.052	20.170	96.04	43.42	121.50	46.35	48.99	.290	626.1	1855.1	51.71	96.06	1214.3	358.0
2.80														
	20.052	20.170	108.72	44.00	134.16	46.93	48.99	.290	632.4	1874.3	51.68	96.03	1440.2	367.1
3.00														
	20.052	20.170	95.00	42.43	120.42	45.36	48.99	.290	639.7	1894.6	51.65	95.99	1223.7	356.4
3.20														
	20.052	20.170	51.91	42.43	77.32	45.36	48.99	.290	647.3	1915.0	51.61	95.96	612.7	360.1
3.40														
	20.052	20.170	47.03	42.41	72.43	45.34	48.99	.290	655.0	1935.3	51.58	95.93	556.4	363.8
3.60														
	20.052	20.170	47.05	42.41	72.43	45.34	48.99	.290	662.8	1955.6	51.55	93.89	563.1	367.7
3.80														
	20.052	20.170	47.06	42.41	72.43	45.34	48.99	.290	670.5	1976.0	51.52	95.86	569.9	371.5
4.00														

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, HIGH PENMN - OXYGEN SUPPLY SYSTEM

MINIMUM REQUIRED ULLAGE PRESSURE FOR 3 ENGINE OPERATION PER MAIN FEED LINE

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
.20	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
.40	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
.60	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
.80	24.205	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
1.00	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
1.20	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
1.40	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
1.60	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
1.80	27.815	22.047	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
2.00	72.780	60.229	50.421	42.600	36.256	31.037	26.648	23.024	20.052	20.052	20.052	20.052
2.20	78.072	63.920	53.079	44.570	37.755	32.203	27.616	23.779	20.551	20.052	20.052	20.052
2.40	65.825	69.328	56.974	47.456	39.950	33.913	28.977	24.883	21.481	20.052	20.052	20.052
2.60	96.041	76.452	62.105	51.259	42.842	36.165	30.799	26.339	22.707	20.052	20.052	20.052
2.80	108.718	85.294	68.473	55.978	46.430	38.959	32.993	28.145	24.227	20.873	20.052	20.052
3.00	94.996	71.527	55.232	43.505	34.802	28.171	23.003	20.052	20.052	20.052	20.052	20.052
3.20	51.909	33.609	21.690	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
3.40	47.029	29.336	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
3.60	47.045	29.352	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
3.80	47.061	29.368	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052	20.052
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE = ORBITER 040A, HIGH PENMN = HYDROGEN SUPPLY SYSTEM

MINIMUM REQUIRED ULLAGE PRESSURE FOR 3 ENGINE OPERATION PER MAIN FEED LINE

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	30.922	30,501	30,484	30,470	30,459	30,450	30,442	30,436	30,430	30,425	30,421	30,417
.20	30.551	30,526	30,506	30,490	30,477	30,466	30,457	30,449	30,443	30,437	30,432	30,428
.40	30.723	30,676	30,638	30,608	30,584	30,563	30,546	30,532	30,520	30,509	30,500	30,492
.60	30.959	30,880	30,818	30,768	30,728	30,695	30,667	30,643	30,623	30,606	30,592	30,579
.80	31.357	31,223	31,118	31,035	30,968	30,912	30,866	30,827	30,794	30,766	30,742	30,721
1.00	32.892	32,544	32,275	32,062	31,890	31,750	31,633	31,536	31,453	31,382	31,321	31,268
1.20	33.655	33,155	32,780	32,489	32,260	32,075	31,924	31,798	31,693	31,603	31,527	31,461
1.40	30.679	30,524	30,430	30,373	30,337	30,315	30,302	30,294	30,290	30,288	30,288	30,289
1.60	31.519	31,257	31,077	30,950	30,858	30,788	30,736	30,694	30,662	30,636	30,614	30,596
1.80	32.233	31,858	31,594	31,403	31,260	31,151	31,065	30,997	30,942	30,897	30,859	30,828
2.00	35.425	34,556	33,922	33,447	33,080	32,792	32,560	32,371	32,215	32,084	31,973	31,878
2.20	35.486	34,449	33,723	33,197	32,805	32,506	32,272	32,086	31,936	31,814	31,711	31,626
2.40	40.097	38,208	36,872	35,897	35,163	34,599	34,155	33,800	33,511	33,273	33,074	32,906
2.60	43.416	40,625	38,694	37,312	36,294	35,525	34,932	34,465	34,091	33,787	33,537	33,329
2.80	43.998	40,669	38,428	36,867	35,748	34,926	34,309	33,836	33,467	33,175	32,941	32,750
3.00	42.434	39,118	36,932	35,445	34,405	33,661	33,116	32,711	32,404	32,168	31,984	31,839
3.20	42.427	39,105	36,916	35,428	34,387	33,643	33,099	32,694	32,388	32,152	31,969	31,825
3.40	42.412	39,091	36,902	35,414	34,375	33,631	33,088	32,684	32,378	32,143	31,961	31,817
3.60	42.413	39,092	36,903	35,415	34,376	33,632	33,089	32,685	32,379	32,144	31,962	31,818
3.80	42.414	39,093	36,904	35,416	34,377	33,633	33,090	32,686	32,380	32,145	31,963	31,819
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, HIGH PENMN - OXYGEN SUPPLY SYSTEM

TANK BOTTOM PRESSURE VALUES FOR 3 ENGINE OPERATION PER MAIN FEED LINE

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	45.549	45.549	45.549	45.549	45.549	45.549	45.549	45.549	45.549	45.549	45.549	45.549
.20	45.549	45.549	45.549	45.549	45.549	45.549	45.549	45.549	45.549	45.549	45.549	45.549
.40	45.548	45.548	45.548	45.548	45.548	45.548	45.548	45.548	45.548	45.548	45.548	45.548
.60	45.548	45.548	45.548	45.548	45.548	45.548	45.548	45.548	45.548	45.548	45.548	45.548
.80	49.700	45.547	45.547	45.547	45.547	45.547	45.547	45.547	45.547	45.547	45.547	45.547
1.00	45.546	45.546	45.546	45.546	45.546	45.546	45.546	45.546	45.546	45.546	45.546	45.546
1.20	45.545	45.545	45.545	45.545	45.545	45.545	45.545	45.545	45.545	45.545	45.545	45.545
1.40	45.543	45.543	45.543	45.543	45.543	45.543	45.543	45.543	45.543	45.543	45.543	45.543
1.60	45.542	45.542	45.542	45.542	45.542	45.542	45.542	45.542	45.542	45.542	45.542	45.542
1.80	53.302	47.535	45.540	45.540	45.540	45.540	45.540	45.540	45.540	45.540	45.540	45.540
2.00	98.264	85.713	75.905	68.083	61.740	56.520	52.171	48.508	45.536	45.536	45.536	45.536
2.20	103.549	89.397	78.556	70.047	63.232	57.681	53.094	49.256	46.020	45.529	45.529	45.529
2.40	111.294	94.796	82.442	72.925	65.418	59.381	54.445	50.352	46.950	45.521	45.521	45.521
2.60	121.498	101.910	87.563	76.716	68.299	61.622	56.226	51.796	48.164	45.510	45.510	45.510
2.80	134.162	110.738	93.917	81.422	71.874	64.403	58.437	53.589	49.671	46.317	45.496	45.496
3.00	120.425	96.956	60.661	68.934	60.231	53.600	48.432	45.481	45.481	45.481	45.481	45.481
3.20	77.321	59.021	47.103	45.465	45.465	45.465	45.465	45.465	45.465	45.465	45.465	45.465
3.40	72.426	54.732	45.449	45.449	45.449	45.449	45.449	45.449	45.449	45.449	45.449	45.449
3.60	72.426	54.732	45.432	45.432	45.432	45.432	45.432	45.432	45.432	45.432	45.432	45.432
3.80	72.426	54.732	45.416	45.416	45.416	45.416	45.416	45.416	45.416	45.416	45.416	45.416
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, HIGH PENMN - HYDROGEN SUPPLY SYSTEM

TANK BOTTOM PRESSURE VALUES FOR 3 ENGINE OPERATION PER MAIN FEED LINE

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	33.458	33.437	33.420	33.407	33.395	33.386	33.378	33.372	33.366	33.362	33.357	33.354
.20	33.487	33.462	33.442	33.426	33.413	33.403	33.393	33.386	33.379	33.374	33.369	33.364
.40	33.659	33.612	33.575	33.544	33.520	33.500	33.483	33.468	33.456	33.446	33.436	33.429
.60	33.895	33.816	33.754	33.705	33.664	33.631	33.603	33.580	33.560	33.543	33.528	33.515
.80	34.293	34.159	34.054	33.971	33.904	33.848	33.802	33.764	33.731	33.702	33.678	33.657
1.00	35.828	35.480	35.211	34.998	34.826	34.686	34.569	34.472	34.389	34.318	34.257	34.204
1.20	36.991	36.091	35.715	35.425	35.195	35.011	34.859	34.734	34.629	34.539	34.463	34.397
1.40	33.615	33.460	33.366	33.308	33.272	33.250	33.237	33.229	33.226	33.224	33.224	33.225
1.60	34.454	34.192	34.012	33.885	33.793	33.724	33.671	33.630	33.597	33.571	33.549	33.532
1.80	35.168	34.793	34.529	34.338	34.195	34.086	34.000	33.932	33.877	33.832	33.794	33.763
2.00	38.360	37.490	36.857	36.381	36.015	35.726	35.495	35.306	35.149	35.018	34.908	34.813
2.20	38.420	37.383	36.657	36.131	35.739	35.440	35.206	35.020	34.871	34.748	34.646	34.560
2.40	43.030	41.141	39.806	38.830	38.097	37.532	37.088	36.733	36.444	36.206	36.007	35.839
2.60	46.349	43.557	41.626	40.244	39.227	38.458	37.864	37.397	37.024	36.720	36.470	36.262
2.80	46.929	43.601	41.359	39.798	38.680	37.858	37.240	36.767	36.399	36.107	35.872	35.681
3.00	45.365	42.049	39.863	38.376	37.336	36.591	36.047	35.641	35.334	35.098	34.915	34.770
3.20	45.357	42.035	39.846	38.357	37.317	36.572	36.028	35.623	35.317	35.082	34.899	34.754
3.40	45.341	42.019	39.831	38.343	37.303	36.559	36.016	35.612	35.306	35.072	34.889	34.745
3.60	45.341	42.019	39.831	38.343	37.303	36.559	36.016	35.612	35.306	35.072	34.889	34.745
3.80	45.341	42.019	39.831	38.343	37.303	36.559	36.016	35.612	35.306	35.072	34.889	34.745
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, HIGH PENMN - OXYGEN SUPPLY SYSTEM

RECOMPUTED ENGINE PRESSURES FOR 3 ENGINE OPERATION PER MAIN FEED LINE

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	94.539	94.539	94.539	94.539	94.539	94.539	94.539	94.539	94.539	94.539	94.539	94.539
.20	91.805	92.195	92.504	92.754	92.958	93.127	93.269	93.389	93.491	93.580	93.656	93.723
.40	91.802	92.192	92.502	92.752	92.957	93.126	93.268	93.388	93.491	93.579	93.656	93.722
.60	89.059	89.842	90.463	90.964	91.373	91.713	91.997	92.237	92.443	92.619	92.772	92.906
.80	63.000	63.962	68.013	71.277	73.946	76.156	78.007	79.572	80.908	82.057	83.053	83.922
1.00	95.734	95.619	95.510	95.411	95.323	95.246	95.179	95.120	95.067	95.022	94.982	94.946
1.20	95.228	95.184	95.132	95.081	95.032	94.987	94.947	94.911	94.878	94.850	94.825	94.802
1.40	94.174	94.283	94.353	94.400	94.432	94.454	94.471	94.482	94.491	94.497	94.503	94.507
1.60	83.143	84.840	86.166	87.224	88.081	88.787	89.374	89.870	90.290	90.651	90.964	91.235
1.80	63.000	63.000	65.535	69.162	72.112	74.546	76.578	78.292	79.750	81.004	82.089	83.035
2.00	63.000	63.000	63.000	63.000	63.000	63.000	63.000	63.000	63.137	65.811	68.122	70.134
2.20	63.000	63.000	63.000	63.000	63.000	63.000	63.000	63.000	63.000	65.276	67.664	69.736
2.40	63.000	63.000	63.000	63.000	63.000	63.000	63.000	63.000	63.000	64.492	66.993	69.152
2.60	63.000	63.000	63.000	63.000	63.000	63.000	63.000	63.000	63.000	63.460	66.110	68.384
2.80	63.000	63.000	63.000	63.000	63.000	63.000	63.000	63.000	63.000	63.000	65.013	67.431
3.00	63.000	63.000	63.000	63.000	63.000	63.000	63.000	64.157	67.372	70.117	72.399	74.319
3.20	63.000	63.000	63.000	69.392	74.963	78.930	81.820	83.968	85.476	86.749	87.744	88.532
3.40	63.000	63.000	65.128	72.733	77.947	81.611	84.243	86.170	87.486	88.594	89.444	90.105
3.60	63.000	63.000	65.112	72.717	77.931	81.595	84.227	86.154	87.470	88.577	89.428	90.089
3.80	63.000	63.000	65.096	72.701	77.915	81.579	84.211	86.138	87.454	88.561	89.412	90.073
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE = ORBITER 040A, HIGH PENMN = HYDROGEN SUPPLY SYSTEM

RECOMPUTED ENGINE PRESSURES FOR 3 ENGINE OPERATION PER MAIN FEED LINE

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
.20	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
.40	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
.60	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
.80	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
1.00	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
1.20	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
1.40	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
1.60	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
1.80	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
2.00	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
2.20	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
2.40	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
2.60	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
2.80	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
3.00	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
3.20	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
3.40	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
3.60	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
3.80	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
4.00												

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, HIGH PENMN - FEED SYSTEM WEIGHTS

PROPELLANT	MAIN FEEDLINE DIAMETER (INCHES)	ENGINE FEEDLINE WEIGHTS LINE NO 1	LINE NO 2	LINE NO3	LINE NO 4	TOTAL ENGINE FEEDLINE WEIGHT	MAIN FEEDLINE WEIGHT	ENGINE FEEDLINE INSULATION WEIGHT	MAIN FEEDLINE INSULATION WEIGHT	TOTAL FEED SYSTEM WEIGHT
OXYGEN	12,000	282,78	289,75	294,18	,00000	866,71	1341,9	15,585	72,077	2296,2
OXYGEN	13,000	282,46	288,95	293,08	,00000	864,49	1565,4	15,585	78,322	2524,8
OXYGEN	14,000	282,46	288,95	293,08	,00000	864,49	1823,6	15,585	84,631	2793,3
OXYGEN	15,000	282,46	288,95	293,08	,00000	864,49	2120,0	15,585	91,002	3091,0
OXYGEN	16,000	282,46	288,95	293,08	,00000	864,49	2445,4	15,585	97,436	3423,0
OXYGEN	17,000	282,46	288,95	293,08	,00000	864,49	2813,1	15,585	103,93	3797,1
OXYGEN	18,000	282,46	288,95	293,08	,00000	864,49	3216,6	15,585	110,49	4207,2
OXYGEN	19,000	282,46	288,95	293,08	,00000	864,49	3657,7	15,585	117,12	4654,9
OXYGEN	20,000	282,46	288,95	293,08	,00000	864,49	4137,9	15,585	123,80	5141,8
OXYGEN	21,000	282,46	288,95	293,08	,00000	864,49	4659,0	15,585	130,55	5669,7
OXYGEN	22,000	282,46	288,95	293,08	,00000	864,49	5222,7	15,585	137,36	6240,2
OXYGEN	23,000	282,46	288,95	293,08	,00000	864,49	5830,7	15,585	144,24	6855,0
HYDROGEN	12,000	291,08	252,21	331,46	,00000	874,75	711,31	,00000	,00000	1586,1
HYDROGEN	13,000	291,08	252,21	331,46	,00000	874,75	871,90	,00000	,00000	1746,7
HYDROGEN	14,000	291,08	252,21	331,46	,00000	874,75	1057,0	,00000	,00000	1931,8
HYDROGEN	15,000	291,08	252,21	331,46	,00000	874,75	1269,5	,00000	,00000	2143,2
HYDROGEN	16,000	291,08	252,21	331,46	,00000	874,75	1508,1	,00000	,00000	2382,9
HYDROGEN	17,000	291,08	252,21	331,46	,00000	874,75	1777,9	,00000	,00000	2652,6
HYDROGEN	18,000	291,08	252,21	331,46	,00000	874,75	2077,8	,00000	,00000	2954,6
HYDROGEN	19,000	291,08	252,21	331,46	,00000	874,75	2416,3	,00000	,00000	3291,1
HYDROGEN	20,000	291,08	252,21	331,46	,00000	874,75	2790,0	,00000	,00000	3664,8
HYDROGEN	21,000	291,08	252,21	331,46	,00000	874,75	3204,3	,00000	,00000	4079,0
HYDROGEN	22,000	291,08	252,21	331,46	,00000	874,75	3663,7	,00000	,00000	4538,4
HYDROGEN	23,000	291,08	252,21	331,46	,00000	874,75	4175,3	,00000	,00000	5050,0

END OF CASE 2

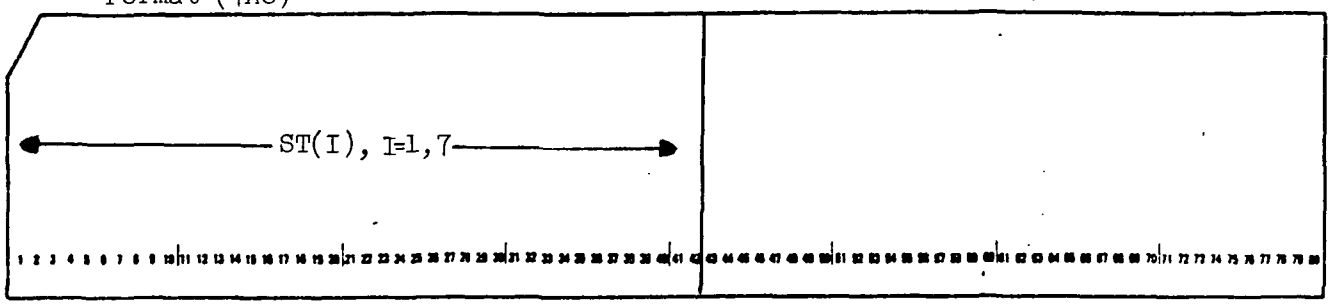
APPENDIX A

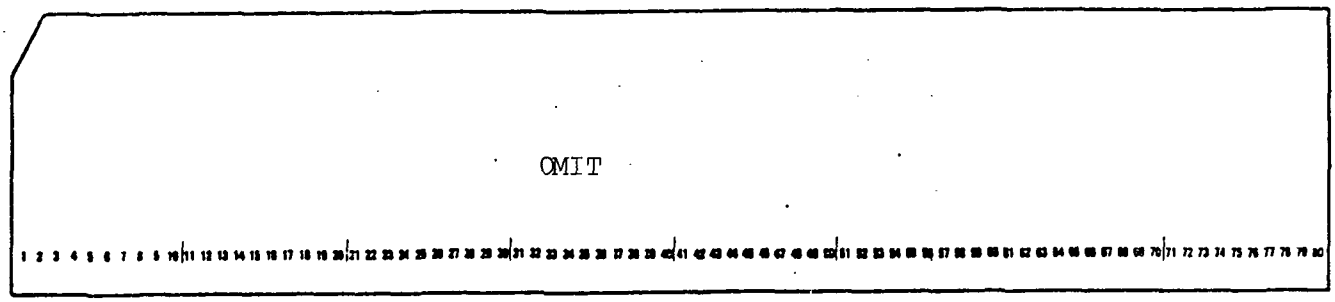
INPUT DATA FORMATS

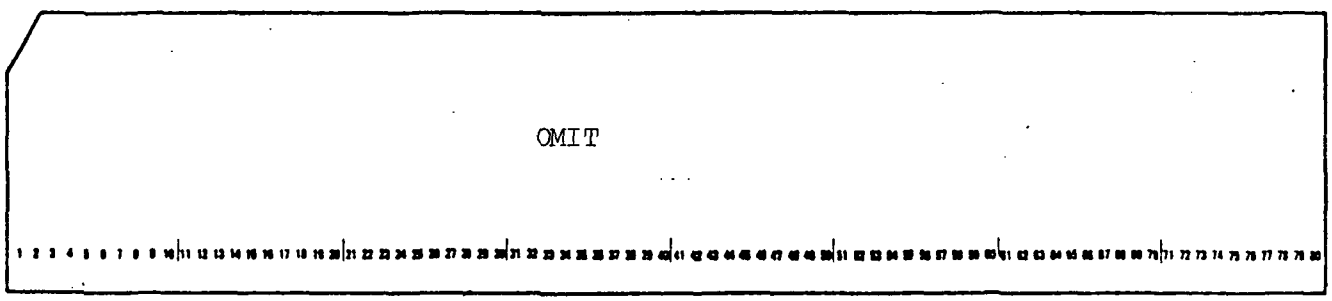
Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE CASE TITLE CARD	Model		
Approved			HEADER CARD NO. 1	Report No.		

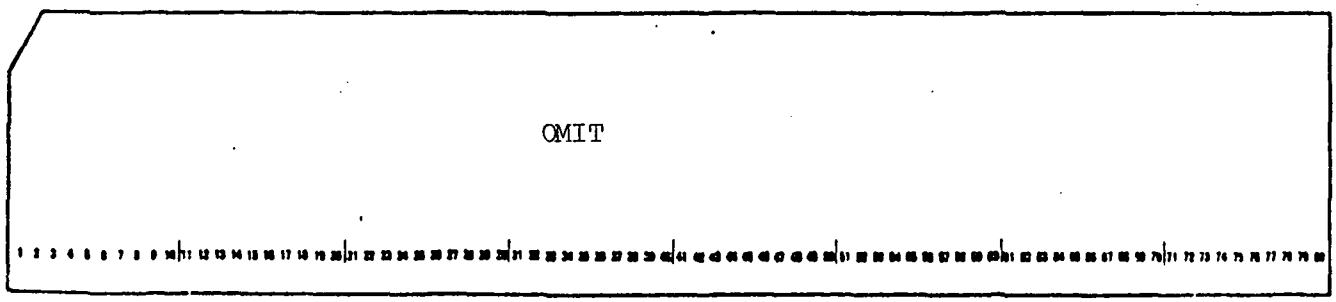
Analysis title card contains heading which is printed on output.

This card must be included as the first card of each case.
Format (7A6)



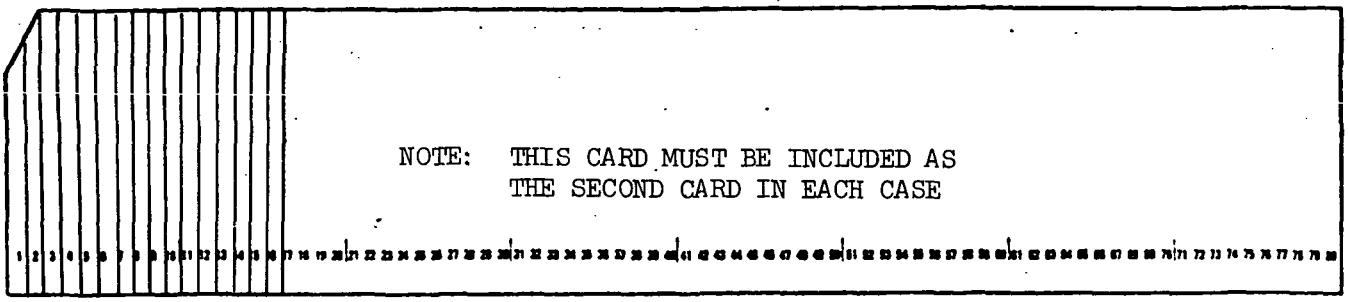




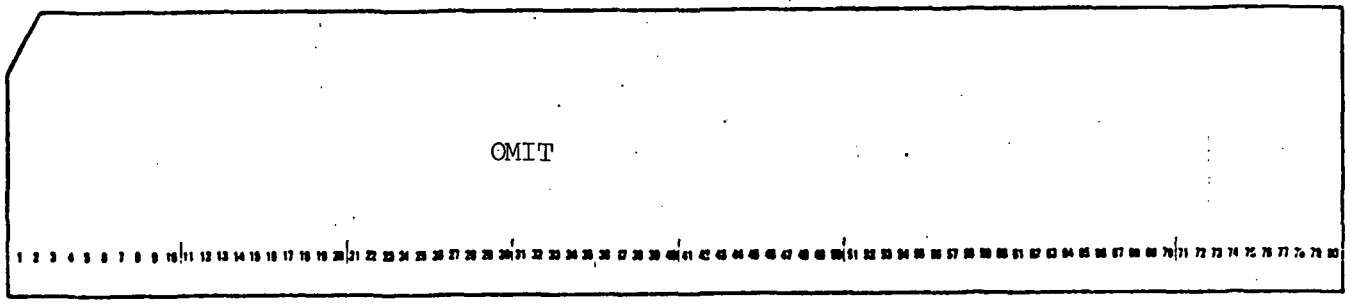


Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE INPUT DATA FLAG CARD	Model		
Approved			HEADER CARD NO. 2	Report No.		

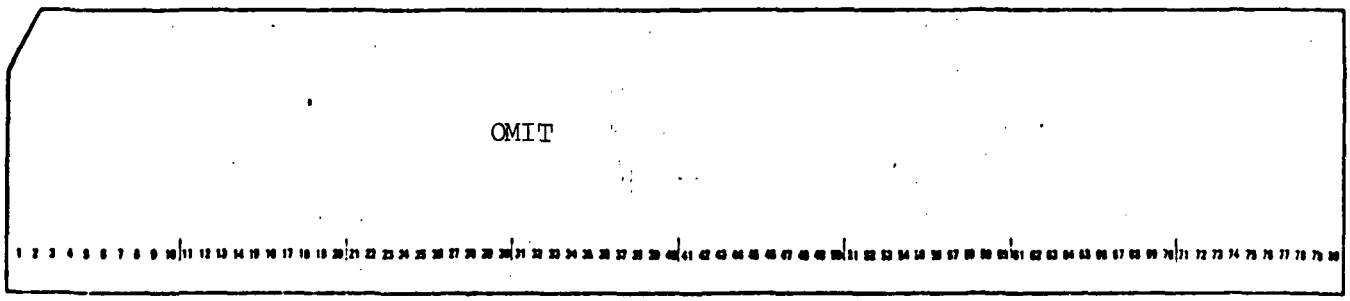
This card contains 16 integer flags corresponding to the 16 input data groups which follow. If IP(IG) = 1, Data Group IG is to be read in; if IP(16) = 0 or blank, Data Group IG is not present.
FORMAT (16I1)



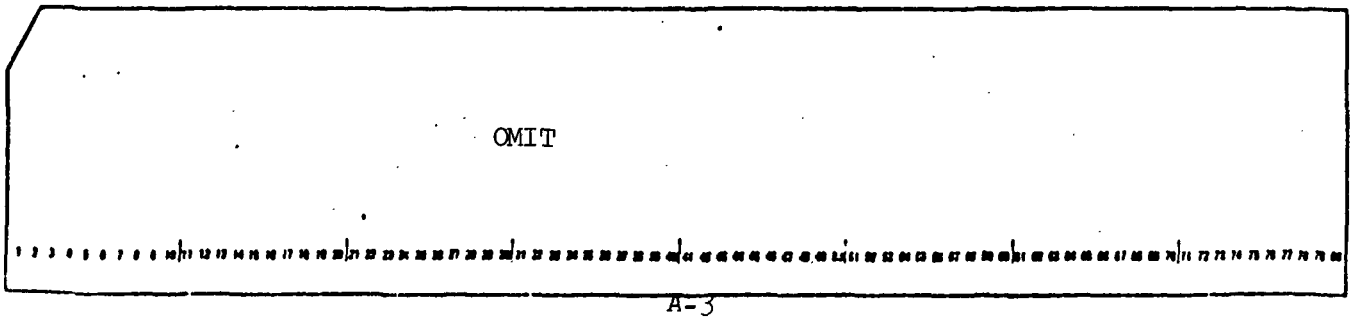
NOTE: THIS CARD MUST BE INCLUDED AS THE SECOND CARD IN EACH CASE



OMIT



OMIT



OMIT

Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE FEED SYSTEM PARAMETERS	Model		
Approved			INPUT GROUP 1	Report No.		

NML - Number of main feedline sizes to be considered (up to 12)
NEL - Number of engine feedline attached to each main line (up to 4)
SYSNUM - If 1, program computes for OXID, feedlines only.
- If 2, program computes for fuel feedlines only.
- If 3, program computes for both feedlines.
NSIZE - Total number of feedlines per tank - NEL + NML

NOP - Number of engines FED by a main feedline

NOPl - Number of engines on vehicle

NPTS - Number of time points being considered in analysis (up to 20)

NGST - Ground start flag (NGST = 2 for ground start)

Format ((1216)). (All inputs right adjusted)

NEL	NML	SYSNUM	NOP	NOPI	NPTS	NGST

TØTLMØ - Total length of oxygen main feedine, ft.
TØTLMH - Total length of hydrogen main feedline, ft.
FØRMAT ((6E12.8))

TØTMLØ	TØTMLH

OMIT

Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE PROPELLANT TANK CONFIGURATION	Model		
Approved			INPUT GROUP 2	Report No.		

EQLR1 - Lengths and Radii of tank sections (see Fig. 9)

Format ((6E12.8))

EQLR1 (1)	EQLR1 (2)	EQLR1 (3)	EQLR1 (4)	EQLR1 (5)	EQLR1 (6)	

EQLR1 (7)	EQLR1 (8)	EQLR1 (9)		

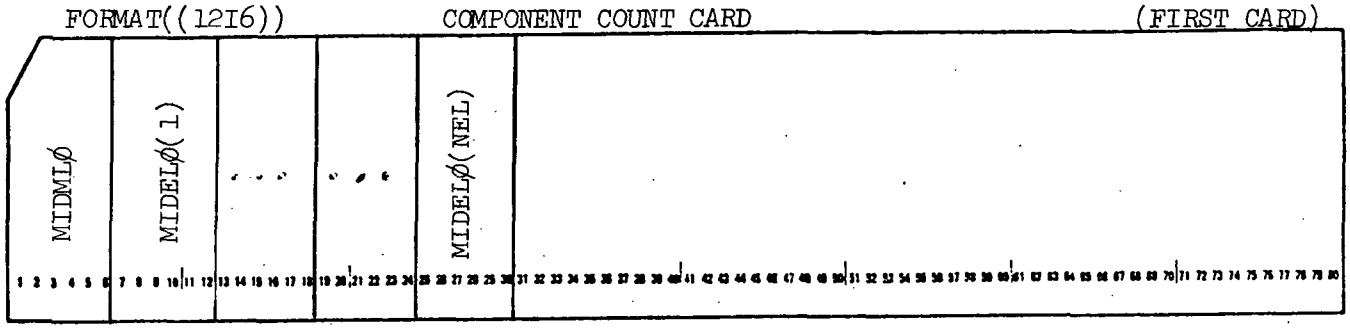
OMIT

OMIT

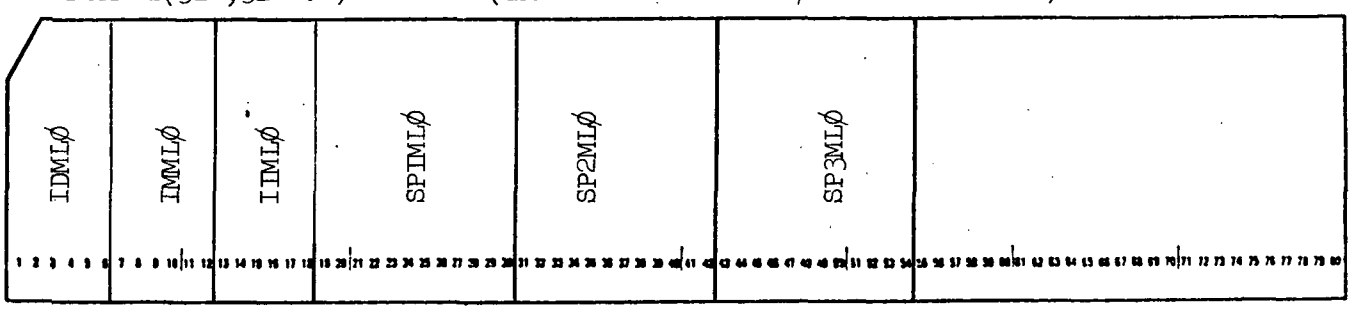
Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE OXIDIZER FEEDLINE CONFIGURATION	Model		
Approved			INPUT GROUP 3	Report No.		

MIDMLO - TOTAL NUMBER OF COMPONENTS IN MAIN OXYGEN FEEDLINE (UP TO 100)
MIDELO(NL)- TOTAL NUMBER OF COMPONENTS IN ENGINE OXYGEN FEEDLINE NUMBER NL (UP TO 100)
IDMLO - COMPONENT TYPE FLAG FOR MAIN OXYGEN LINE
IMMLO - COMPONENT MATERIAL FLAG FOR MAIN OXYGEN LINE
IIMLO - COMPONENT INSULATION FLAG FOR MAIN OXYGEN LINE
IMLO - SUBSCRIPT DENOTING COMPONENT POSITION IN MAIN OXYGEN FEEDLINE (IMLO = 1 AT TANK BOTTOM)
IELO(NL)-SUBSCRIPT DENOTING COMPONENT POSITION IN ENGINE OXYGEN FEEDLINE (IELO(NL) = MIDELO(NL) AT INLET TO ENGINE NO, NL)
SP1MLO(I),SP2MLO(I),SP3MLO(I) - COMPONENT SPECIFICATIONS (SEE MANUAL)
OPD(K),K=1,NEL - DIAMETERS OF OXYGEN ENGINE FEEDLINES (INCHES)
OPD(K),K-NEL+1,NSIZE - CANDIDATE DIAMETERS OF MAIN OXYGEN FEEDLINE (INCHES)

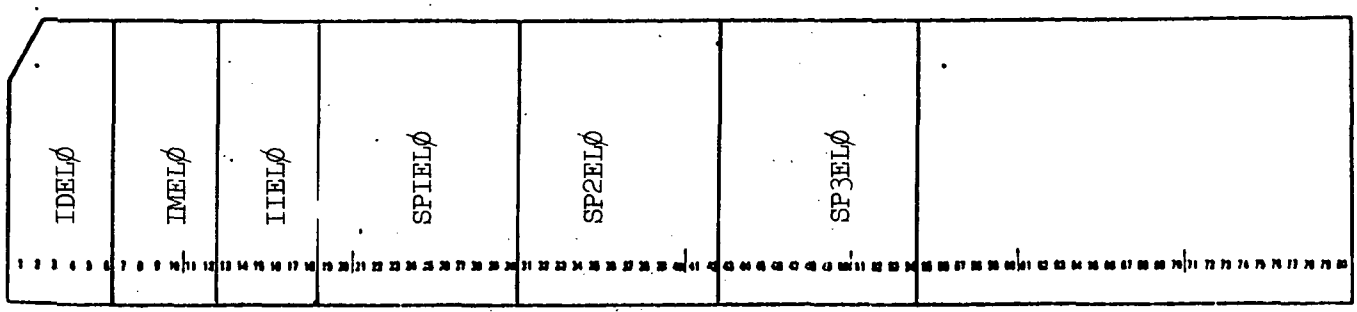
FORMAT((12I6)) COMPONENT COUNT CARD (FIRST CARD)



FORMAT(3I6,3E12.8) COMPONENT DESCRIPTOR CARDS FOR MAIN FEEDLINE (THERE MUST BE MIDMLØ OF THESE CARDS)



FORMAT (3I6,3E12.8) COMPONENT DESCRIPTOR CARDS FOR EACH ENGINE FEEDLINE (THERE MUST BE MIDELØ(NL) OF THESE CARDS FOR EACH ENGINE FEEDLINE NO'S 1 TO NEL)



Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE OXIDIZER FEEDLINE CONFIGURATION	Model		
Approved			INPUT GROUP 3 (Continued)	Report No.		

Oxidizer Feedline Diameter Cards

Format ((6E12.8))   NSIZE = NEL + NML

OPD (1)	. . .	OPD(NEL)	OPD(NEL+1)	. . .	OPD(NSIZE)	

← ENGINE FEEDLINE DIAMETERS → | ← MAIN FEEDLINE DIAMETERS →

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FORM MSO 592A

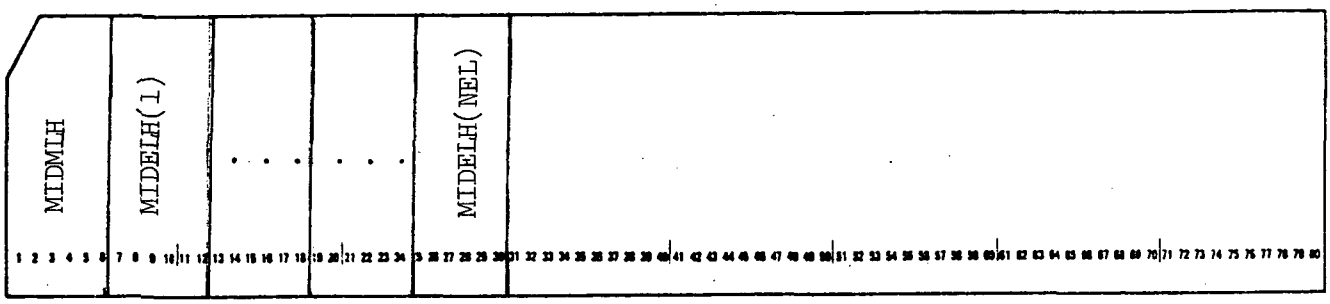
Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE FUEL FEEDLINE CONFIGURATION	Model		
Approved			INPUT GROUP 4	Report No.		

MIDMLH - TOTAL NUMBER OF COMPONENTS IN MAIN HYDROGEN FEEDLINE (UP TO 100)
MIDELH(NL) - TOTAL NUMBER OF COMPONENTS IN ENGINE HYDROGEN FEEDLINE NUMBER NL (UP TO 100)
IDMLH - COMPONENT TYPE FLAG FOR MAIN HYDROGEN LINE
IMMLH - COMPONENT MATERIAL FLAG FOR MAIN HYDROGEN LINE
IIMLH - COMPONENT INSULATION FLAG FOR MAIN HYDROGEN LINE
IMLH - SUBSCRIPT DENOTING COMPONENT POSITION IN MAIN HYDROGEN FEEDLINE (IMLH = 1 AT TANK BOTTOM)
IBLH(NL)-SUBSCRIPT DENOTING COMPONENT POSITION IN ENGINE HYDROGEN FEEDLINE (IELH(NL) = MIDELH(NL) AT INLET TO ENGINE NO,NL

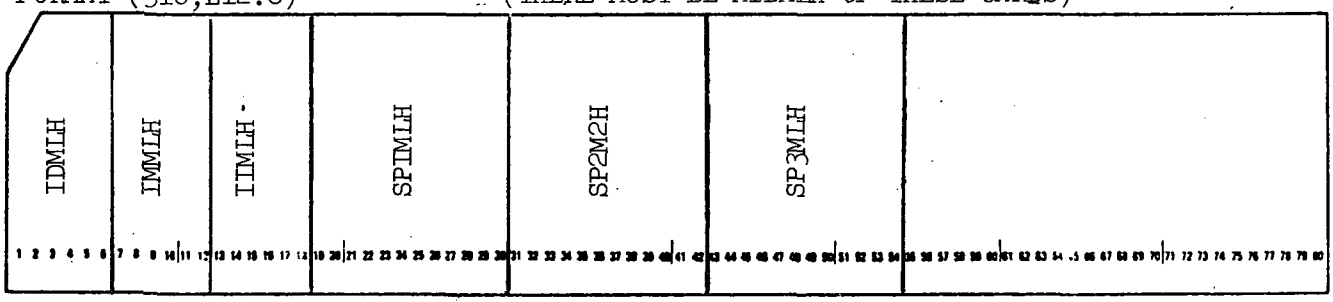
SP1MLH(I),SP2MLH(I),SP3MLH(1) - COMPONENT SPECIFICATIONS (SEE MANUAL)

HPD(K),K=1,NEL- DIAMETERS OF HYDROGEN ENGINE FEEDLINES (INCHES)
HPD(K),K=NEL+1,NSIZE - CANDIDATE DIAMETERS OF MAIN HYDROGEN FEEDLINE (INCHES)

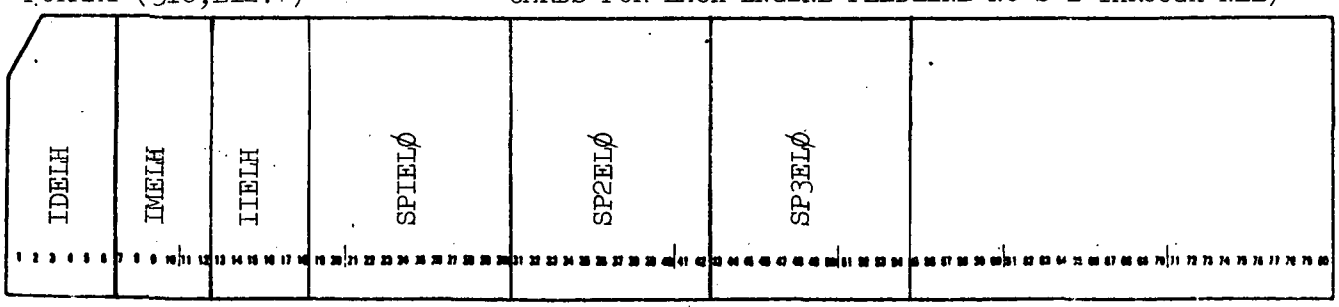
FORMAT ((12I6)) COMPONENT COUNT CARD (FIRST CARD)



FORMAT (3I6,E12.8) COMPONENT DESCRIPTOR CARDS FOR MAIN FEEDLINE (THERE MUST BE MIDMLH OF THESE CARDS)



FORMAT (3I6,E12.8) COMPONENT DESCRIPTOR CARDS FOR EACH ENGINE FEEDLINE (THERE MUST BE MIDELH(NL) OF THESE CARDS FOR EACH ENGINE FEEDLINE NO'S 1 THROUGH NEL)



Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE FUEL FEEDLINE CONFIGURATION	Model		
Approved			INPUT GROUP 4 (CONTINUED)	Report No.		

Fuel Feedline Diameter Cards

FORMAT ((6E12.8))   NSIZE = NEL + NML

HPD(1)	. . .	HPD(NEL)	HPD(NEL+1)	. . .	HPD(NSIZE)	

← ENGINE FEEDLINE DIAMETERS → ← MAIN FEEDLINE DIAMETERS →

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Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE FEEDLINE HEIGHTS AND DESIGN	Model		
Approved			PRESSURES - INPUT GROUP 5	Report No.		

OXHTLN - FEEDLINE HEAD HEIGHT ABOVE ENGINE INLET,OXID, (FT)
HYHTLN - FEEDLINE HEAD HEIGHT ABOVE ENGINE INLET,FUEL, (FT)
PDLO - OXYGEN FEEDLINE DESIGN PRESSURE (OPTIONAL) (PSI)
PDLH - HYDROGEN FEEDLINE DESIGN PRESSURE (OPTIONAL) (PSI)

NOTE: A FACTOR OF SAFETY OF 2.5 IS APPLIED BY THE PROGRAM TO THE ABOVE PRESSURES IN THE COMPUTATION OF LINE WALL THICKNESSES, IF (PDLO,PDLH),LE,0, PROGRAM USES MAXIMUM TANK BOTTOM PRESSURE OR ENGINE INLET PRESSURE.

FORMAT ((6E12.8))

ØXHTLN	HYHTLN	PDLØ	PDLH	
1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24	25 26 27 28 29 30 31 32 33 34 35 36	37 38 39 40 41 42 43 44 45 46 47 48	49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

OMIT

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE INITIAL WEIGHTS	Model		
Approved			INPUT GROUP 6	Report No.		

LOADO1 - LOADED WEIGHT OF OXIDIZER, LB.
LOADH1 - LOADED WEIGHT OF FUEL, LB.
VWGTN - TOTAL VEHICLE WEIGHT AT IGNITION, LB.

FORMAT ((6E12.8))

LØADØ1	LØADH1	VWGTN	

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

OMIT

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

OMIT

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE STEADY-STATE ENGINE CONDITIONS	Model		
Approved			INPUT GROUP 7	Report No.		

WDOTNO - OXIDIZER NOMINAL FLOW RATE FOR SINGLE ENGINE (LBS/SEC)
WDOTNH - FUEL NOMINAL FLOW RATE FOR SINGLE ENGINE (LBS/SEC)
FNOM - NOMINAL THRUST FOR SINGLE ENGINE (LBS)

FORMAT ((6E12.8))

WDØTNØ	WDØTNH	FNØM	
1 2 3 4 5 6 7 8 9 10 11 12	13 14 15 16 17 18 19 20 21 22 23 24	25 26 27 28 29 30 31 32 33 34 35 36	37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

OMIT

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

OMIT

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE ENGINE INLET CONDITIONS	Model		
Approved			INPUT GROUP 8	Report No.		

TENINO - TEMP. OF OXID. FLUID AT ENGINE INLET (DEG. R)
TENINH - TEMP. OF FUEL FLUID AT ENGINE INLET (DEG. R)
TLIQSO - TEMP. OF OXID. FLUID SURFACE IN TANK DEG. R
TLIQSH - TEMP. OF FUEL FLUID SURFACE IN TANK DEG. R
PENTOL - ENGINE INLET FLUID PRESSURE TOLERANCE (PSI)

FORMAT ((6E12.8))

TENINØ	TENINH	TLIQSØ	TLIQSH	PENTØL	

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Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE TIME VALUES FOR TRANSIENT DATA	Model		
Approved			INPUT GROUP 9	Report No.		

TIMEA - TIME VALUES OF EVENTS IN TRANSIENT (UP TO 21)

FORMAT ((6E12.8))

TIMEA(1)	TIMEA (2)	. . .	. . .	TIMEA(NPTS)		

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Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE PROPELLANT FLOWRATE HISTORY	Model		
Approved			INPUT GROUP 10	Report No.		

WDTFRO - FRACTION OF OXIDIZER FLOW RATE AT TIMEA(I)
WDTFRH - FRACTION OF FUEL FLOW RATE AT TIMEA(I)

FORMAT ((6E12.8)

WDTFRØ(1)	WDTFRØ(2)	. . .	. . .	WDTFRØ(NPTS)		

NOTE: WDTFRH DATA START ON A NEW CARD

WDTFRH(1)	WDTFRH(2)	. . .	. . .	WDTFRH(NPTS)		

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Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE ENGINE START THRUST HISTORY	Model		
Approved			INPUT GROUP 11	Report No.		

FIFRAC(I) - FRACTION OF NOMINAL THRUST (FOR A SINGLE ENGINE) AT TIMEA(I)

FORMAT ((6E72.8))

FIFRAC(1)	FIFRAC(2)	. . .	. . .	FIFRAC(NPTS)		

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Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE SUCTION PRESSURE REQUIREMENTS	Model		
Approved			INPUT GROUP 12	Report No.		

NPSPO - NET POSITIVE SUCTION PRESSURE FOR OXIDIZER PSI
NPSPH - NET POSITIVE SUCTION PRESSURE FOR FUEL PSI

FORMAT((6E12.8))

NPSPØ(1)	NPSPØ(2)	. . .	. . .	NPSPØ(NPTS)		

NOTE: NPSPH DATA START ON A NEW CARD

NPSPH(1)	NPSPH(2)	. . .	. . .	NPSPH(NPTS)		

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Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE ENGINE INLET PRESSURE REQUIREMENTS	Model		
Approved			INPUT GROUP 13	Report No.		

PENMNO - MINIMUM ENGINE INLET OXID. PRESSURE VALUE AT TIMEA PSIA
PENMNH - MINIMUM ENGINE INLET FUEL PRESSURE VALUE AT TIMEA PSIA

FORMAT ((6E12.8))

PENMNØ(1)	PENMNØ(2)	. . .	. . .	PENMNØ(NPTS)		

NOTE: START A NEW CARD FOR PENMNH DATA

PENMNH(1)	PENMNH(2)	. . .	. . .	PENMNH(NPTS)		

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Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE NON-CONDENSIBLE PRESSURANT DATA	Model		
Approved			INPUT GROUP 14	Report No.		

PPDGOT - PART,PRESS. OF PRESSURANT GAS IN OXID. TANK PSI
PPDGHT - PART,PRESS. OF PRESSURANT GAS IN FUEL TANK PSI

FORMAT ((6E12.8))

PPDGØT(1)	PPDGØT(2)	. . .	. . .	PPDGØT(NPTS)		

NOTE: START A NEW CARD FOR PPDGHT

PPDGHT(1)	PPGHT(2)	. . .	. . .	PPDGHT(NPTS)		

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OMIT

Prepared	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Checked			TITLE PRESSURANT GAS TEMPERATURES	Model		
Approved			INPUT GROUP 15	Report No.		

TDGOT - TEMP. OF PRESSURANT GAS, IF NONE-SET EQUAL TO TLIQSO + 5, DEG.R
TDGHT - TEMP. OF PRESSURANT GAS, IF NONE-SET EQUAL TO TLIQSH + 5, DEG.R

FORMAT ((6E12.8))

TDGØT(1)	TDGØT(2)	. . .	. . .	TDGØT(NPTS)		

NOTE: START A NEW CARD FOR TDGHT

TDGHT(1)	TDGHT(2)	. . .	. . .	TDGHT(NPTS)		

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	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Page	TEMP.	PERM.
Prepared						
Checked			TITLE End of Data for a Case	Model		
Approved			INPUT GROUP 16	Report No.		

IGØØN=1, there is another case to be processed following this one.

IGØØN=0, this is the last case of the run. Terminate processing and return control to the computer operating system: FORMAT ((12I6))

IGØØN	

NO FOLLOWING DATA CARDS ARE REQUIRED

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